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Nonpoint Source Control Guidance, Agricultural Activities

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Water Planning Division

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

February 3, 1978

SUBJECT: Transmittal of Document Entitled "Nonpoint Source Control Guidance, Agricultural Activities"

FROM : Merna Hurd, Director
Water Planning Division Merna Hurd

TO : Regional Water Division Directors
208 Coordinators
NPS Coordinators
State and Areawide Water Quality Management Agencies

TECHNICAL GUIDANCE MEMORANDUM - TECH - 44

Purpose report

This "Nonpoint Source Control Guidance, Agricultural Activities," has been prepared to provide State and areawide WQM agencies and other concerned groups with assistance in the development and implementation of programs to control nonpoint sources of pollution resulting from such activities. It has been deliberately written in a form that is easy to follow so that the reader does not have to be an expert in the field to understand what the problems are and some of the solutions that are available.

Guidance

The agricultural nonpoint source guidance document is the last of an initial series of documents prepared in accordance with policies and procedures of 40 CFR, Part 131: "EPA will prepare guidelines concerning the development of water quality management plans to assist State and areawide (WQM) planning agencies in carrying out the provisions of these regulations." The others involved construction (December, 1976), hydromodification (February, 1977), silviculture (March, 1977), and mining (December, 1977). Prepared in accordance with 40 CFR, Part 131, it presents technical and management guidance information regarding problem identification and assessment, information needs and analyses, and Best Management Practices. Activities discussed include irrigated and non-irrigated crop production and confined and pastured/grazing animal production.

Enclosure

EPA 440/3-78-001

NONPOINT SOURCE CONTROL GUIDANCE

AGRICULTURAL ACTIVITIES

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Agricultural Stabilization and Conservation Service
Extension Service
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Pesticides Monitor
Environmental Defense Fund, Inc.

American Society of Agronomy

American National Cattleman's Association

National Association of Conservation Districts

National Agricultural Chemicals Association

The Conservation Foundation

Cont

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NONPOINT SOURCE CONTROL GUIDANCE
AGRICULTURAL ACTIVITIES

INTRODUCTION

The impact of agriculture on the nation's waters is significant as over 506 million hectares (1,250 million acres) of land are used for agricultural, grazing and closely related purposes. About 157 million hectares (388 million acres) are used for crop production. In 1975, 1.6 billion cubic meters (420 billion gallons) of water per day were withdrawn from surface and ground sources for use in the United States. Although irrigation uses only 35% of this total quantity, it consumes over 82% of the total amount of fresh water consumed in the U.S. (360 million cubic meters, or 96 billion gallons per day). Consumed water represents that water used and no longer available because it has been evaporated, transpired, incorporated into crops or products, consumed by animals or people, and otherwise extracted from the environment.

The present trends in agriculture involve employing modern techniques at ever increasing levels of complexity for the use of fertilizers, pesticides, irrigation systems and confined animal feeding facilities. A natural result of these trends could be an increased potential for pollution of both ground and surface waters if control of the nonpoint soures of pollution does not receive equal emphasis.

Preventing water quality degradation must become a major concern of the 208 planning agency and the agricultural community. Agricultural activities discussed in the nonpoint source control guidance document are subdivided into two main categories: (1) crop production, (2) animal production. Each activity can be separated further into subcategories if local conditions dictate the need.

To a large extent, local climatic events such as precipitation, wind, and the overland flow of water govern the generation and runoff of pollutants resulting from agricultural activities. Other natural or other conditions which have a strong influence include soil and vegetative characteristics, geologic conditions, and topography. Even in irrigated areas, where supplemental water is applied to the ground at a controlled rate, the land is subject to the same powerful influences of highly variable natural forces. As a result, the runoff of pollutants from lands affected by agricultural activities is subject to drastic and often unpredictable variations.

Nonpoint source pollutants resulting from agricultural activities include sediments, nutrients, pesticides, salts, organic materials, and pathogens. Sediment resulting from soil erosion is regarded as the greatest pollutant, by volume, that affects water quality. Agricultural lands, particularly cropland, are large contributors of excess sediment in the United States. The national conservation needs inventory of the Department of Agriculture's Soil Conservation Service estimated in 1971 that the total sediment yield from cropland per year was more than 0.9 billion metric tons (1 billion tons). Cropland is responsible for over 50% of the total national sediment yield to inland waterways. Finer-grained portions of this sediment often carry with them significant quantities of plant nutrients, pesticides, organic and inorganic matter, pathogens, and other water pollutants.

About 1.8 billion metric tons (2 billion tons) of livestock wastes are produced annually. As much as 50% of these wastes may be produced in confined facilities. While most of these waste materials are confined and eventually spread on farm acreage, runoff and seepage from these sources pose a potentially significant pollution hazard.

Commercial fertilizers consumed during 1976 amount to about 44 million metric tons (49 million tons) in the United States. About 75% of this quantity is used by farmers. Some of the nutrients from the fertilizers are transported, together with naturally occurring nutrient elements, to surface and groundwaters.

Pesticides are designed to be lethal to target organisms, but many are toxic to nontarget organisms. Four major categories of importance to agriculture are insecticides, fungicides, herbicides, and rodenticides. Of nearly 454 million kilograms (1 billion pounds) of pesticides applied in the United States during 1970, about 70% was for farm use. It is anticipated that the use of of pesticides will greatly increase during the next 20 years.

The threat from pesticides results from their persistence in the aquatic environment. Fish and other food chain organisms accumulate pesticides and their metabolites or degradation products. Adverse effects often result in high biological organisms which have consumed contaminated organisms lower in the food chain. This phenomenon is termed biological magnification. It appears to be especially significant with pesticides that have a very low solubility in waters.

Irrigated agricultural activites involve the application of supplemental water supplies to the land. Salts are introduced by the water and concentrated by evaporation and transpiration processes. The applied water also leaches additional salts from the soils in the area and transports them, in return flows, to downstream areas. About 60% of irrigation waters are lost by evapotranspiration. The remainder is returned by surface runoff and by subsurface flow to surface and groundwaters. These return flows can carry large quantities of minerals and degrade the water quality of the receiving streams.

Organic nonpoint pollutants from agricultural activites result from animal wastes, crop residues, and other sources. When these substances reach a water body, they often exert a high biochemical oxygen demand (BOD).

Agricultural wastes may be a source of pathogens. When these wastes come in contact with water, plants, and animals they may transmit disease-carrying organisms. Losses caused by infectious agents of livestock and poultry have been substantial.

The disposal of solid wastes is addressed by the Resource Conservation and Recovery Act (RCRA) of 1976. With the exception of animal wastes applied to the land as soil conditioners and solid or dissolved materials in irrigation return flows, any discarded material, including solid, liquid, semi-solid, or contained gaseous material resulting from agricultural operations will ultimately be subjected to the authority of RCRA. This authority has been established to insure proper handling of hazardous wastes and environmentally sound disposal of all solid wastes.

Important factors to consider in preventing, or minimizing, the generation or runoff of nonpoint source pollution in the agricultural areas include: controlling erosion caused by water or wind; optimizing use of the proper pesticides and fertilizers; effective containment and disposal of animal wastes on land; and increasing the efficiency of the irrigation delivery systems and water management methods for pollution control purposes. Measures for controlling the agricultural nonpoint sources of pollution from agricultural activities will be discussed in detail in Chapter 3, "Selected Best Management Practices".

Other sections of this document include:

Chapter 1 - "Existing Problem Identification and Assessment".

Chapter 2 - "Information Needs and Analyses for The Selection of Best Management Practices".

Chapter 4 - "Methodololgy for Assessment of Potential Agricultural Nonpoint Source Pollution Problems"

CHAPTER 1

EXISTING PROBLEM IDENTIFICATION AND ASSESSMENT

Identification of Agricultural Activities and Their Related Pollutants

Agricultural activities responsible for the production of food and fiber are viewed as two major categories, (1) crop production and (2) animal production (Table 1-1). These have been further clarified as non-irrigated crop production, irrigated crop production, confined animal production, and pastured/grazing animal production. The water pollution potential of these activities has increased considerably due to intensified production requirements.

TABLE 1-1

Agricultural Production Activities and Related Pollutants

	Crop Production		Animal Production	
Pollutants	Irrigated	Non-irrigated	Confined	Pastured/ Grazing
sediments	o	x	o	x
nutrients	o	o	x	o
salts	x	--	o	--
organics	o	o	x	o
pesticides	o	o	--	--
pathogens	--	--	o	o

x = Principal problem resulting from activity
o = Secondary problem
-- = Minor problem, if any

Crop Production:

The pollutants which generally result from non-irrigated crop production are sediments, nutrients, and pesticides. Organics, such as crop residues also may cause water quality problems.

Sediments: These materials are defined as mineral or organic matter in fragment form. Deposited into water bodies, they can cover fish spawning areas, clog the channels of rivers and coat the bottoms of lakes, reduce light transmission in water, and increase pesticide and nutrient loadings through the chemicals and other pollutants they have adsorbed. As a result, water quality is impaired, navigation hampered, and aquatic life threatened. The fine-grained fractions of sediment are especially threatening because of their affinity for association with available pesticides and nutrients, susceptibility to erosion and transport processes, and inherent ability to pass through many of the applied erosion and sediment control measures.

A major factor causing accelerated erosion and the production of sedimentary materials is the practice of leaving the ground surface devoid of vegetative cover and exposed to the erosive effects of rain, wind, and runoff water during a large portion of the year. Such barren, exposed ground may be the result of a fall plowing operation. A third to one-half of the year is recognized as the growing season across the major agricultural areas of this country. In many instances, the ground is left bare the remaining one-half to two-thirds of the year. Where residue has been left on the surface it often is inadequate to protect the soils from erosion forces.

Although the emphasis on erosion and sediment problems thus far has been with respect to water, wind erosion is an increasing threat to arid or semi-arid western agricultural lands. Wind-borne sediments are likely to be deposited in low-lying areas where they can be transported to nearby water bodies.

Nutrients: Nitrogen, phosphorous, and potassium (N, P, and K) are the three major plant nutrients. Commercial fertilizers make up the major portion of the N, P, and K used in crop production. The rest is supplied through the recycling of animal manures and from natural background sources (soils, legumes, atmospheric conditions, etc.). Nutrients utilized by vegetation are soluble in a soil solution with solubilities varying with the composition of the materials. As a result, nutrients may become a threat to water quality if they are applied in excess and transported, by runoff, from the area of application into water bodies. High concentrations of some nutrients in water may be toxic to humans or animals; however, the principal problem caused by nutrients is accelerated eutrophication in water bodies.

Pesticides: Many pesticides are highly toxic to fish and other aquatic life and can persist in aquatic environments for long periods of time. They can be applied from the air, from the surface, or injected into the soils.

Wherever crop management is conducted to maximize production, there may be a subsequent increase in pest and plant diseases associated with the crop. Where certain crops are grown year after year in an area (monoculture), a population of pests and/or plant diseases specific to these crops may develop resistance to a consistently used pesticide. In these cases, effective control may be achieved by using heavier doses or more frequent use of the same pesticide, by alternating pesticides or combinations of pesticides, rotating crops, or by pesticide-crop rotation combinations.

Organics: Organic pollutants result from crop residue and other materials that have been transmitted from the agricultural areas into water bodies. They can exert a high biochemical oxygen demand (BOD) and may even deplete the supply of oxygen to kill certain forms of aquatic life.

Irrigated Crop Production

Many of the nonpoint source problems associated with irrigated crop production are similar to those associated with non-irrigated crop production discussed previously. The addition of irrigation water increase the pollution potential of croplands with respect to salts, sediments, and other pollutants associated with sediments. Special problems related to salts and sediments are discussed below.

Salts: Excess quantities of mineral salts from irrigation return flows comprise the principal pollution problem in many of the irrigated river basins of the West. Irrigation waters applied to croplands must provide for the evapotranspiration needs of the crop as well as a leaching fraction to wash salts from the plant root zone. Evapotranspiration processes result in a net increase in the salt content of the water not used by the crops. When this water moves into surface or ground waters it degrades their quality and causes pollution. In time, salts also will accumulate in the soils and, unless removed by leaching with excess quantities of applied water, will cause crop reductions or failure. Water quality and crop production thus are closely interrelated.

Sediments: Sediment losses associated with irrigated crop production are related to the type of irrigation system used, and the character of the land under cultivation. Approximately 80% of the irrigated land in the U.S., 19 million hectares (48 million acres) receives water by surface application methods. Flooding and furrow irrigation involve 30% and 50% of the acreage respectively (Reference No. 1-1).

In furrow irrigation, the crops are planted along the slope of the land in order to facilitate the movement of water to all parts of the field under gravity flow. This practice increases the sediment yield from fields as the flowing water can erode and transport sediment particles.

Sprinkler irrigation systems are used extensively in the mid-western and western states. Many new areas, not readily amenable to surface systems, are being developed under sprinkler irrigation methods. Generally, these lands are more susceptible to erosion, especially when the vegetative cover is removed. Fortunately, ,sprinkler systems, can be designed to apply the rate and quantity of water in accordance with soils and topographic conditions and to include vegetative and structural erosion control management practices. This will act to prevent runoff and the resultant erosion and transport of sediments.

Confined Animal Production

The pollutants most closely associated with confined animal production facilities are nutrients, organics, sediments, salts, pesticides and pathogens. They have been the cause of considerable water degradation in the past and, unless controlled, will continue to cause water quality problems in the future.

Nutrients: The quantity and type of nutrients found in animal manures vary significantly with the type of animals confined and the feeding ration used. Nitrogen and phosphorus are two nutrients readily found in them. The nitrogen content of manures will vary from .2% to 1.8% by weight depending upon many variables, including time (Reference No. 1-3). The phosphorus content, however, does not change appreciably with time.

Various forms of the nutrients (NO_3^-, NH_4^+, PO_4^{---}) are soluble in water and readily move with the flow of water. Nutrients in these forms represent an immediate pollution potential whereas those tied to more complex compounds may not. They become available more slowly and over a longer period of time.

Organics: Organic materials in animal manures vary from rapidly biodegradable cell masses to slowly biodegradable lignins. During biodegradation, nutrients for plants become available, depending upon the type of organic material and the type of microorganisms assimilating it. If they reach water bodies, organics can impose an immediate and/or a long term threat to water quality. The severity of pollution resulting will depend upon their concentration and the relationship between the organic materials and the physical character of the receiving waters.

Sediments: Both mineral and organic sedimentary matter are potential pollutants from confined animal production facilities. Mineral sediments generally result from the soils within unpaved feedlots whereas animal manures are the source of the organic materials. Sediments often are associated with a variety of other pollutants such as nutrients and pesticides which may cause additional water degradation.

Salts: Saline materials associated with animal manures result from animal rations used for increasing weight production. Excess salts in feed rations pass through the animals and remain in the manures. Where concentrations of manures occur on the land, saline conditions can result in the soils. Rainfall or runoff water can leach salts from both the soils and the manures and cause ground and surface water degradation.

Pesticides: In confined animal feeding, pesticides are used for control of insects and other pests. When reaching the soil/manure surface, pesticide particles associate themselves with the solids and solution portions of the manure pack to increase their pollution potential.

Pathogens: Pathogens are the cause of many bacterial, mycoplasmal, spiroplasmal, rickettsial, viral, fungal, and other diseases in animals and man. These microorganisms can be transported in water and may or may not persist in the environment depending upon many factors. In 1967 the World Health Organization estimated that more than 150 diseases were transferable between animal and man. The potential exists for pathogen contamination of swimming and drinking waters when animals or their wastes can reach them (Reference No. 1-3).

Pastured/Grazing Animal Production

Animals on pasture or range may pose a threat to water quality when the land is overstocked or where high concentrations of animals congregate, such as sources of water, salt, and shade. The full effect of overgrazing on water quality in nearby water bodies is not definitely known; however, since it removes protective vegetation from the ground surface, compacts and damages the soil structure by trampling, and leaves organic and other potential pollutants as litter on the ground surface, the potential for water pollution is real. Grazing activities, particularly overgrazing, must be considered potential generators of excess sediments, nutrients, organic materials, and pathogens. When excess quantities of these materials are transported into water bodies they will cause pollution.

Sediments: Pasture and range lands generally become a nonpoint source of pollution when overstocking or continued grazing removes a high percentage of the vegetative cover and leaves soil surfaces exposed to the elements. The subsequent erosion and loss of sediments create the potential for water degradation.

Nutrients: Nutrients from manures and decaying vegetation may become pollutants, particularly near streams or in low-land lake regions used for winter pasture where snow melt or runoff can quickly carry them to the water. The initial buildup of droppings during the spring of the year have been a suspected cause of water degradation in several low-land lakes (Reference No. 1-4). Nutrient problems are usually most critical where animals congregate at water, salt, and shade sources in the pasture or at the farmstead. Excess nitrates from animal manures could become a ground water quality problem in localized areas where animals congregate.

Pathogens: It has been recognized that fecal coliform organisms can occur immediately downstream from areas where animals tend to concentrate. Localized contamination of surface water, groundwater, and the soil itself could result from animals in pastures and perhaps ranges. Although fecal coliform themselves are not pathogenic they indicate that a pathogen could exist and possibly flourish. Fecal streptococci may also be a reliable and definitive measure of human or animal pollution (Reference No. 1-3). Maintaining the health of the animals is critical and proper management of the herd, its by-products, and exposed land areas, is essential.

Assessment of Existing Nonpoint Sources of Pollution from Agricultural Activities

Each of the agricultural activities discussed in this document are somewhat similar in that they all can generate many of the same types of major pollutants sediments, nutrients, pesticides and salts. The magnitude and extent of each type of pollution from crop production activites and from animal production facilities, however, are different. They are uniquely characteristic of the type of activity involved and so may require different assessment techniques for determining problems and problem areas.

The initial phases of any assessment program to determine existing nonpoint sources of pollution must involve compilation and evaluation of all available information that is pertinent to the problem. This type of information should include water quality analyses; stream-flow records; pollution reports; sediment-loss studies; and reports or recorded data on fish kills, eutrophication of lakes, increased ground or surface water salinities; and reservoir sedimentation surveys. Much of the needed information can be obtained from local, State, and Federal agencies such as the Soil Conservation Districts; State Conservation, Fish and Game, Resource, and Water Quality Control organizations; U.S. Geological Survey, Bureau of Reclamation, Soil Conservation Service, Agricultural Stabilization and Conservation Service, Corps of Engineers, Bureau of Land Management; and others. Many times newspaper articles, reports in local periodicals, or complaints made by individuals or environmental groups can be valuable sources of information regarding existing problems. They may involve both surface or ground water pollution.

Sediment can probably be considered the major pollutant caused by agricultural activities as it results from both crop and animal production activities. As nutrients, pesticides, and other pollutants can become fixed to the fine-grained sediment particles, in areas where they have been used, these pollutants should be suspected as problems when excess sediment losses are occurring.

If excess sediment losses are occurring from a nonpoint source area, even one where no visible signs of erosion are apparent, sedimentary deposits should be observable immediately downstream where gradients are reduced. Sediment in ditches, culverts, or drainageways or on vegetated waterways indicate excess losses are occurring. Records or reports by County, State, or Federal road or highway departments regarding maintenance costs for removing sediment deposits from ditches, culverts or roadways are important sources of data for assessing nonpoint source of pollution resulting from agricultural areas. Additional data can be reports and recorded information on turbidity removal within drinking water plants required to obtain and maintain water supplies for industries and municipalities, quantities of sediment dredged from rivers to maintain their conveyance capacity, and progressively larger deposits of sediments on land and in water bodies downstream from an area of intensive agriculture.

Sheet erosion by water cannot be readily detected by visual observation. A loss of 5 tons per acre per year would be only several thousandths of an inch thick. Where erosion becomes severe, rills and gullies may become visual on slopes and deposited sediments even more extensive in areas where water gradients decrease.

In semi-arid areas, sediments eroded by prevailing winds may be observed as deposits where wind velocities have decreased. Their sources will be located farther in an upwind direction where visual observations of erosion may indicate there whereabouts. Excess wind erosion is also apparent by blowing dust which reduces visibility and makes highway driving dangerous. Unless stabilized quickly by some type of vegetation or other control measure, this wind-blown sediment will be transported by runoff into drainageways and create pollution problems.

Excess sediment deposits can be detected in small ponds or lakes downstream from agricultural source areas where sediment losses are high. Deltas form at the upstream end of these water bodies as a result of excess sediment loads carried by streams. Deposits of sediment also form where a stream that is heavily laden with sediment enters a larger and slower moving stream.

Many reservoirs are surveyed periodically by Federal or State agencies to determine sediment deposits accumulating in them. These reservoir sediment deposition surveys present a particularly important reservoir of data to determine where soil losses from agricultural activities are extensive. A report entitled "Summary of Reservoir Sediment Deposition Surveys Made in the United States" provides information on these surveys (Reference No. 1-5). It presents reservoir information obtained by many agencies and is periodically updated. More detailed data on each reservoir can be obtained by request from the supplying agency. The average annual sediment accumulation per square mile of drainage can be obtained from this document.

Where erosion on agricultural lands becomes severe and runoff water concentrates, rills and gullies form. When this kind of erosion is noted, it can be quickly identified as a nonpoint source of pollution. Even if the locality is a considerable distance from a stream and much of the sediment is deposited, it is merely a question of time before another runoff event carries it into a water body. The quantity of sediment being eroded from the area can be estimated by determining the length, width, and depth of the rills or gullies and computing their total volumes. An estimated "bulking factor" can be assigned to determine the volume of sediment to be derived from a given volume of in-place soil. This factor indicates that the material occupies a greater volume after it is eroded than it does before.

Another method of assessing or estimating pollution sources in an area where sediment problems seem apparent is to evaluate the soil conservation program to determine if soil losses affected by agricultural activities exceed the annual limits of from 2 to 5 tons per acre. These are the figures set by soil scientists to maintain fertility and productivity for soils over a period of time and can be considered compatible with pollution control goals unless proven otherwise. For shallow, or thin soils, these loss figures have been reduced to as low as one ton per acre per year. If conservation factors in the soil loss equation such as the cover and management factor (C) and supporting practices factor (P) have been improperly installed or maintained, or even not installed at all, soil losses for the area will exceed the limit and potential pollution sources and problems are indicated (Reference Nos. 1-6 through 1-8).

If no conservation program exists in an area of high stream sediment loads, the soil losses, and pollution sources, also can be evaluated through the use of the USDA's Universal Soil Loss Equation (Reference Nos. 1-7 and 1-8). This equation estimates annual sediment, or soil losses through the use of rainfall and runoff erosivity indices, soil erodibility factors, slope factors, and cover and management and supporting practice factors. Since the latter two factors have not been implemented for erosion control purposes they must be estimated from the percent of ground cover or, assumed that they provide no control, and are thus valued at 1. Values for all of the various factors involved in the soil loss equation can be obtained from Reference Nos. 1-8 through 1-10; U.S.G.S. topographic maps, U.S. Weather Bureau, Technical Papers; U.S.D.A. soils bulletins; and other sources provided at the end of Chapter 2.

The nonpoint sources of pollutants other than sediment are even more difficult to assess than readily visible sediment. Wastes from organic materials can show up as debris. Soluble pollutants and materials which adsorb to fine-grained sediment particles can be identified by leaching and analyzing samples of fine-grained sediments deposited in nearby water bodies for suspected materials. Analyzing sediment samples obtained during reservoir sediment deposition surveys can be an extremely useful tool for indicating pesticide, nutrient, and other pollutant losses from an agricultural source areas. Toxic materials in runoff may be apparent downstream from source areas by fishkills and evidence of excess nutrients by algal blooms in water bodies.

Salts on lands resulting from irrigation return waters often are visually apparent, particularly in topographically depressed areas, as light-colored dessicated deposits of salts. Saline surface water return flows are concentrated in these areas where the water stands until evaporated by the sun. If the subsurface water table is close enough to the ground surface, saline water also may be drawn to the surface by capillary action in the soils and evaporated to leave salts on the surface as residue. Sampling and testing of this water from various depths beneath the ground surface should substantiate conclusions regarding ground or surface sources of the pollutants.

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CHAPTER 2

INFORMATION NEEDS AND ANALYSES FOR THE SELECTION OF BEST MANAGEMENT PRACTICES

INTRODUCTION

Pollutants resulting from agricultural nonpoint sources of pollution have been a cause of water quality problems for some time. The Environmental Protection Agency and the U. S. Departments of Agriculture and Interior, as well as other Federal organizations and State agencies, have been concerned for the past several years about the effects of sediments, nutrients, salts, pesticides, organics, and pathogens within the rural community. Therefore, much information is available which can be used for problem analysis and control solutions (See References and Appendix A).

Information needs relative to nonpoint source control vary with respect to the state-of-the-art of, (1) the control techniques and methodologies developed thus far and, (2) the data base upon which these techniques and methodologies depend. Extension of the state-of-the-art of methodologies and the associated information is not the primary objective of water quality management. Rather, implementable water quality management programs which are always based upon the most current state-of-the-art are the goal. Since much of the information required in water quality management planning has already been generated, it needs only to be collected and evaluated in order to design effective control systems of Best Management Practices.

Precipitation and runoff water are the principal agents responsible for the generation and transportation of pollutants from the agricultural areas of any watershed. During dry seasons in the west, supplemental water applied for irrigation purposes can perform these functions. Precipitation, whether it falls as rain or snow, is the main source of all water moving through a drainage basin. The natural topographic conditions, characteristics of the soils and vegetative coverings occurring in the basin, and the results of man's changing of these natural characteristics during his agricultural activities, govern how much runoff water results from a given quantity of precipitation.

Since local climatic events such as rainfall, snowmelt, surface runoff, and wind, to a large extent, control the loss of pollutants from an agricultural area, these factors must be considered when developing effective Best Management Practices. Data are needed regarding the velocity, rate, and quantity of runoff water, or other waters applied to the ground surface; physical and chemical characteristics of soils and underlying geologic materials; length, steepness, and roughness of slopes; effectiveness of the vegetative crop cover in the area; and effects of alteration of these factors by the agricultural activities being conducted. Alterations of the natural drainage system is extremely important and the drainage area above as well as below the agricultural area should be evaluated.

Basic Information Needs

In order to select the most appropriate and economical selection of Best Management Practices, basic information must be gathered which will outline the physical, climatological, and managerial conditions under which nonpoint source pollution occurs. Once this information is gathered, its evaluation should reveal these management practices which have the greatest potential to reduce or prevent water degradation. A water quality management plan should recognize the agricultural activities being conducted in an area and the management programs needed at the local level and recommend management alternatives which will reduce the pollution potentials.

Precipitation

Data on precipitation can be obtained from several sources. Published data on daily rainfall measured at standard gages are available principally from the National Weather Service, Department of Commerce (formerly the U. S. Weather Bureau) in monthly issues of "Climatological Data". Other Federal and State agencies or universities publish rainfall data on an irregular basis, often in special storm reports or research papers. Unpublished data are available from various Federal and State agencies as a result of field surveys following unusually large storms. These surveys some times have obtained, from local people, measurements of rainfall caught in buckets, bottles, and similar containers. They provide added detail to rainfall maps developed from standard rain gage data.

To make the information more useful for hydrologic work, the National Weather Service published analyses of rainfall data in the fifty States, Puerto Rico, and the Virgin Islands (Reference Nos. 2-1 through 2-4). The western States also are covered by the National Oceanic and Atmospheric Administration's Precipitation Atlas 2 (Reference No. 2-5). Methods for making a more precise analysis of the data is presented in publications such as the Soil Conservation Service's "National Engineering Handbook, Section 4 Hydrology", the Bureau of Reclamation's "Design of Small Dams" and others (Reference Nos. 2-6 and 2-7). They provide essential information for determining, or estimating, the amount of rainfall to be expected in the area; the intensity, duration and seasonal distribution of storms with associated probabilities of occurrence; the antecedent conditions in the drainage, and other factors.

Wind Data

Sediments blowing off cultivated areas may be a serious problem in areas where noncohesive soils occur, particularly in arid or semiarid regions. Data regarding the capacity of the wind to cause erosion, the prevailing wind directions, and the preponderance of wind erosion forces in the prevailing directions are presented in U.S. Department of Agriculture Handbook No. 346 "Wind Erosion Forces in the United States and Their Use in Predicting Soil Loss", (Reference No. 2-8).

Characteristics of Soils and Underlying Geologic Materials

Evaluation of available soils information is of particular importance for development of Best Management Practices. It will include such factors as the texture, structure, permeability, chemical characteristics, etc. Many of these characteristics are interrelated and all may have an effect on the generation and movement of pollutants from agricultural lands. Data on possible groundwater bodies underlying the site are also essential. The depth to the ground water and its quality and direction of movement should be determined. It could possibly introduce waters into the site area to carry pollutants into or from the area to degrade adjacent supplies.

Information regarding the physical characteristics of soils and/or underlying geologic materials in site areas can be obtained from soil survey reports published by the U. S. D. A., Soil Conservation Service, in cooperation with other Federal or with State agencies; geologic reports provided by Federal, State, and local agencies; from documents available from universities or other institutions of higher learning; and from conservation district offices in counties. This information often is generalized as it is done on an areawide basis and usually for a different purpose than pollution control. The level of detail of the information in such documents varies according to the objectives of the work but they can be valuable for conducting an analysis of hazards and potentials and for the development of Best Management Practices.

Specific soils data and other information regarding in-place characteristics of geologic materials beneath the ground surface can be obtained from agricultural soils bulletins, prior studies or case histories of problem areas. Additional, more detailed information can be derived by sampling the materials at the sites and evaluating the properties of the materials sampled.

Ground Water Conditions

Subsurface water conditions are of critical importance as the inflow of poor quality ground water into an area can be the cause of pollution problems. Movement of surface runoff waters containing pollutants into an underlying ground water body can also cause pollution. Data needed for pollution prevention with regard to ground water includes depth to the water body, direction of movement, whether it occurs under confined (artesian) or unconfined (water table) conditions, and its natural quality. Ground water information may be obtained from U. S. Geological Survey Water-Supply Papers and other technical reports, State water development agency reports, from local data obtained regarding studies of wells and the quality of water produced by them in the site area, and other sources.

Topographic Conditions

An evaluation of topographic conditions in an area, can be made from information on existing maps such as the Geological Survey's topographic maps, the Department of Agriculture's soil maps, and other maps of this type. More detailed data on topography and conditions will usually be available from the conservation plans prepared by the Soil Conservation Service.

The length, steepness, and roughness of slopes are important and may be determined through actually surveying the site or from interpretation of the published reports discussed above, as well as from the topographic maps developed by the U.S. Geologic Survey, Army Map Service, and other sources.

Pesticides Usage

Use of pesticides is restricted by Federal law; and State and local restrictions also may apply. In order to limit the possibility of pesticides creating detrimental environmental effects as a result of agricultural activities, strict adherence to label directions is required. In the past, all pesticides were listed in issues of the "EPA Compendium of Registered "Pesticides", which could be obtained from the Superintendant of Documents, U.S. Government Printing Office. This document provided information on dosages and application rates, tolerances, formulations, use limitations, and pests controlled. It is now outdated and being replaced by "EPA Index of Registered Pesticides: Their Limitations and Restrictions," which is under preparation by the Office of Pesticides Programs. Pesticide application rates should conform to registered label directions and application equipment cleaned or disposed of properly (Reference Nos. 2-9 through 2-11). Data on pesticide uses also can be obtained from each State's Cooperative Extension Service.

Fertilizers Usage

Plant nutrients such as nitrogen, phosphorus, and potassium, which are present in fertilizers, often create pollution problems. Many other chemicals are present in minor quantities in the fertilizers (See Table 2-1). They may have been added to make up for soil nutritional deficiencies or merely occur as impurities. These minor chemicals are not considered to represent potential pollution problems.

	Nutrient Content
Nitrogen	
Anhydrous Ammonia	82% N
Urea	45% N
Ammonium Nitrate	33.5% N
Liquid Nitrogen Solution	28-38% N
Ammonium Sulfate	21% N
Calcium Cyanamide	21% N
Calcium Nitrate	16% N
Sodium Nitrate	16% N
Urea-Formaldehyde	38% N
Phosphorus	
Rock Phosphate *	2% P
Normal Superphosphate	9% P
Concentrated Superphosphate	21% P
Phosphoric Acid	23% P
Potassium	
Muriate of Potash (KCl)	51% K
Potassium Sulfate (K_2SO_4)	43% K
Sulfate of Potash-Magnesia	19% K
Multinutrient	
Monoammonium Phosphates	11-16% N, 8-20% P
Diammonium Phosphates	16-18% N, 20% P
Ammonium Polyphosphates	10-15% N, 14-30% P
Potassium Nitrate	13% N, 37% K

*Contains 12 to 14% total phosphorus

Table 2-1 Plant-available Nutrients In Common Fertilizers. (Reference No. 2-12)

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The pollution potential from fertilizers will generally be highest where greater quantities of materials are applied. The Following Table 2-2 provides data on the percentage of the acreage of different crops that are fertilized in the U.S. and the national average quantity applied.

Crop	Acres harvested (million)	Percent fertilized		Pounds/acre	
		N	P	N	P
Corn	63.7 (25.8 hectares)	94	87	103 (18.9 Kg/hectares)	27 (5.0)
Cotton	13.1 (5.3 hectares)	79	58	78 (14.3 Kg/hectares)	23 (4.2)
Soybean	52.5 (21.2 hectares)	22	28	15 (2.8 Kg/hectares)	18 (3.3)
Wheat	64.1 (25.9 hectares)	66	46	46 (8.4 Kg/hectares)	17 (3.1)

Table 2-2 Acres Receiving Fertilizer and Average Fertilizer Quantities Used For Four Crops in The United States in 1974. (After Reference No. 2-12)

Fertilizers can be mixed and blended to provide the desired nutrient content. They may be prepared and applied as solids (granules), powders, liquids, suspensions, or slurries. If free ammonia is available in a fluid, it must be injected into soils under pressure.

Many states require that fertilizers sold shall meet specific requirements, be properly labeled, and be registered with the State. Some permit licensing of the firm. Information must be provided in the label concerning the fertilizer net weight, guaranteed analysis, and grade, and the name and address of registrant. The grade gives the percent of elemental nitrogen (N), available phosphorus (P_2O_5), and soluble potash (K_2O).

Agricultural practices

Information is needed regarding existing agricultural management practices, and their relation to pollution control, in order to adequately define and develop Best Management Practices for nonpoint source pollution control. It should include, where appropriate, such things as the:

(1) timing and type of tillage operations conducted and soil and conservation measures used;

(2) crop rotations;

(3) timing and amount of irrigation water applied;

(4) control runoff from farm areas, feedlots, etc.;

(5) timing, type, and quantity of pesticides and fertilizers used; and

(6) disposal areas for pesticides, petroleum products, toxics, etc.

Management practices information for all phases of agricultural activity are available from the U.S. Department of Agriculture, particularly it's local offices and many other State and local agricultural and conservation organizations. A change in management practices can result in widespread beneficial effects on water quality (Reference No. 2-13).

Crop production: Tillage operations which involve the turning, or disturbance of soils for agricultural purposes generate the greatest potential for erosion by both wind and water. The tillage system that best fits a farm operation depends on the crops to be grown, soil characteristics, and local climatic conditions. Tilling on the contour (in a direction perpendicular to the slope of the land) provides for more water conservation and erosion protection than tilling parallel to the slope (up and down hill). It reduces the velocity of runoff flow and increases infiltration.

Stripcropping is used to break the length of the slope into segments by creating vegetated strips across the natural slope of the land. Grasses and other close-growing cover crops are used to provide more soil protection than row crops such as corn and grain sorghum. Crops that leave large quantities of residue after harvest offer more soil protection than crops which only have small quantities of residue. Continuous row cropping may deplete the organic matter (the decaying plant and animal residue) in some soils and thereby decrease water infiltration and increase erodibility.

Runoff water control structures and other facilities are important for proper agricultural management. Diversions are constructed across the slope to intercept excess runoff and divert it to a stable outlet. They are generally constructed above cropland fields, gully headcuts, or other critical areas to reduce the volume of runoff water entering the problem area. Grassed waterways are natural or constructed outlets used to safely dispose of runoff from fields, diversions, terraces, and other conservation measures. Terraces are generally applied to fields where contouring, stripcropping, and tillage operations do not offer adequate soil protection. They break the length of the slope into shorter segments and reduce volume and velocity of runoff water. Many modern diversion and terrace systems utilize buried pipe rather than grassed waterways for outlets.

Irrigated Crop Production: The type of irrigation method used is an important factor when considering development of Best Management Practices for an area. Surface irrigation methods require uniform slopes without obstructions, while sprinkler systems are generally free from land form limitations. Many of the presently-used structural sediment control measures would disrupt the flow of water in surface applied systems where their use under sprinkler system management would not. In the initial design of an irrigation system, the flow of water selected is to provide the quantity of water required to meet agronomic and leaching demands. The management of the system, whether surface or sprinkler type, should result in just meeting these demands as closely as possible with no excess water applied.

The soils and vegetative cover characteristics in each area also play an important role in determining the design of the irrigation system. The quantity of water applied to erosive soils or to crops providing little cover (vegetables, etc.) will be different than that applied to soils which are not erosive and to cover crops which provide a maximum of cover and root stability. The information needs for design include a variety of parameters which describe the soil water plant relationship under consideration. These parameters include:

1. Soil characteristics such as moisture holding capacity, cation exchange capacity, pH, permeability, etc.
2. Crop root zone depth.
3. Plant moisture requirements.
4. Irrigation system efficiencies.
5. Daily evapotranspiration from the crop area.
6. Quality of irrigation water.

The topographic conditions must be known in order to design for water flows which are relatively non-erosive, based upon crop needs and soils conditions. Data needed involve principally length and steepness of slopes and the erodibility of the soils.

More detailed descriptions of the information needs and the use of that information may be obtained from the U. S. Department of Interior, Bureau of Reclamation (Reference No. 2-14) or the U. S. Department of Agriculture, Soil Conservation Service (Reference No. 2-15). The methods described in these references are available in computerized form as well as chart/curve form. Both of these methods organize the data in a systematic fashion and estimate the water use requirement on a weekly, monthly, or seasonal basis.

Confined Animal Production: The information needs in planning for the control of this source include (1) that required for on-lot control and (2) that required for manure disposal/utilization areas. Information needed with respect to the location and hydrologic design of confined animal production facilities must involve a consideration of the following factors:

Climatic parameters (wind, rainfall)
Characteristics of animal wastes
Soil conditions (for unpaved lots)
Topography
Management scheduling of operations
Location relative to water bodies, both surface and ground waters.
Number of animals involved.

The initial facility design needs hydrologic information to provide for runoff controls which will prevent water from invading confinement areas as well as controlling that water which results from precipitation within these areas. Animal manures removed from the facilities and utilized in crop production to provide crop nutrients and improve soil tilth may be a source of pollution if no control measures are provided. Information needs with respect to this source have been outlined under "fertilizers" in crop production. Applying manures in amounts consistent with crop demands is suggested in order to minimize losses of nutrients and the nonpoint source pollution potential.

The application of animal wastes to the land in an environmentally sound manner, and to coincide with the agronomic demand, is the thrust of a recent handbook sponsored by EPA "A Manual For -- Evaluating Land

Applications of Livestock and Poultry Residue" (See abstract in Appendix A). This document presents a method and outlines the information required to determine manure application rates to agricultural lands.

Salts found in animal manures have been a cause of crop production losses and increased salinities in soils. In the western States, particularly semi-arid areas, a consideration of the salt content as well as the nutritional value of animal wastes must be made prior to applying them to the land. Information needed with respect to the salts include the relationship between salinity of the manure and the soil solution as well as the ability of the crops to tolerate salts.

Pesticides used in confined animal production include those for control of insects and other pests. They generally become associated with the manure pack although they may be used in areas adjacent to the feedlot. Information required for preventing runoff of pesticides will involve which management and application practices are available for effective control. Since pesticides often are transported on sediments, information discussed previously regarding sediment control is also needed.

Pathogen control in feedlot and associated facilities involves runoff control, dust control, and especially animal hygiene enhancement. Information is needed concerning the type of animal and pathogen under consideration, disposition of the wastes, areas being contacted by the pathogen and their sensitivity, and the pre-treatment conducted.

Pastured and Grazing Animal Production: Sediment and nutrient problems resulting from pastured animals usually are connected with overgrazing and concentrating animals around salt, water, and shade sources. Data needed for control includes the types and characteristics of the pathogens; their avenues of movement to water bodies or other animals; and topographic, soils, vegetation, and climatic conditions. Much of the information needed is centered around the habits of various animals and the growth potential of various pasture and range plants.

Analysis of Data

Erosion by water and the resulting soil losses from an agricultural area is negligible until runoff actually occurs. The quantity and frequency of precipitation needed to initiate runoff is a function of the interrelationship of many variables such as the rainfall intensity, temporary surface storage in the area, physical character of soils or underlying geologic materials, time since prior precipitation has occurred, location and percentage of the area protected by vegetation, and steepness and length of slopes at the site.

Runoff Determination

The combined effect of soils, vegetative cover, man's earth-changing activities on the amount of rainfall that actually becomes runoff from an area can be estimated in several ways. Probably the most applicable is presented in the Soil Conservation Service's "National Engineering Handbook, Section 4, Hydrology" (Reference No. 2-6). It provides information on estimating runoff through the use of Watershed Curve Numbers. Similar information is presented in this same Agency's "Engineering Field Manual" (Reference No. 2-15). The curve numbers (CN's) are hydrologic "soil-cover" complex numbers which indicate their relative value as direct runoff producers. The higher the number, the greater the amount of direct runoff to be expected from a storm. Existing hydrologic data which has already been developed for agricultural conservation projects, or for other purposes, in the area can also be used.

Estimating Water-caused Sediment losses

Losses from specified agricultural land uses may be estimated through the use of the Universal Soil Loss Equation (USLE). It will provide a long term average annual soil loss from a land area, only a portion of which may reach a stream within a specific time period. Nutrients and pesticides can be associated with these sediments, however, the quantity in association at any one time varies tremendously with the timing, type, and amount of nutrients and pesticides applied.

The following brief discussion presents the soil loss equation and an explanation of the various factors that are involved in a soil loss determination. More detailed descriptions of the methodology can be found in Reference Nos. 2-12, 13, 16, and 17.

$$A = RKLSCP$$

where A = the estimated average annual soil loss in tons per acre

R = the rainfall and runoff erosivity index (a measure of the erosive force of specified rainfall)

K = the soil-erodibility factor (average soil loss per acre per unit of R above.

L = the length of land slope (ratio of soil loss of the field to that from a specific test plot of length 72.6 feet)

S = the land slope, in percent (ratio of soil loss of the field to that from a specific test plot with a gradient of 9%)

C = the ground cover and management factor (ratio of soil loss from the field to that of a field under fallow conditions)

P = the supporting practice factor (ratio of soil loss from the field with support practices such as contouring, strip-cropping, or terracing to that with straight-row, up and down slope farming)

Notice that factors R, K, L, and S pertain to the climate, soil, and topography, and therefore are site-specific. The management factors, L, C, and P, may be changed by man's activities to reduce sediment losses. In this manner erosion control management schemes may be selected based upon a given sediment loss, A. These three factors, L, C, and P, are man's tools for obtaining an "economically achievable" sediment control plan.

Sediment losses resulting from the more severe gully erosion result from changes on the ground which have influenced the characteristics of surface flow or the forces which resist these flows. Once a gully channel is established, the concentrated flow will sustain constant erosion. The channel will widen and headward (upslope) erosion will continue until manmade changes are initiated to restore the original hydraulic stability. Detailed information to determine rates of erosion are presented in Reference No. 2-18.

Estimating Wind-caused Sediment Losses

Wind-blown soils lost from agricultural lands poses serious problems in the arid or semi-arid areas of sandy soils of the western United States. These types of soil losses from a field disturbed by agricutural activities of one kind or another depend upon the surface roughness, moisture content, and cohesiveness of the soils; quantity, type and arrangement of the vegetation or crops grown; velocity of the wind; and on the wind "fetch", or distance across the field that the wind can move without an obstruction changing its velocity.

Information on effects of soils and residues on wind erosion are available. Published information on wind forces, however, is limited and data for design of control practices generally meager. Probably the most useful document available for determining wind forces applicable to the assessment of erosion of field soils and for design of wind-erosion control practices is the Agricultural Handbook No. 346 (Reference No. 2-8). Data presented in it include prevailing wind erosion directions, relative magnitude of erosion forces and their capacity to cause erosion, and the preponderance of erosion forces in the prevailing directions.

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CHAPTER 3

SELECTED BEST MANAGEMENT PRACTICES

Introduction

Implementation of Best Management Practices to reduce or prevent the generation and runoff of nonpoint source pollution caused by farm or ranch agricultural activities should receive a major emphasis from all people and organizations involved. Because these management practices are key factors in reducing the pollution potential of our farms and ranches, it is necessary to evaluate existing agricultural practices which have known or suspected potential to pollute and replace them with BMP's which reduce or eliminate pollution. A preventive approach to pollution control is emphasized in this guidance document, as a result, proper planning prior to conducting the activities involved is essential. To conduct operations and then attempt to control nonpoint source pollution with a "crises-oriented" approach deserves nothing but skepticism.

Best Management Practices for control of nonpoint source pollution also have secondary benefits which should be recognized. Many of them are very closely associated with conservation and the long-term productivity of the natural resources being utilized --- soils, nutrients, etc.

Pollution prevention through the use of Best Management Practices is the main theme presented in this chapter. Some of these practices have been used extensively for many years by some farmers and ranchers in the operation of their agricultural programs. The examples illustrated in this chapter represent a few of the many management practices available, which will result in control of nonpoint source pollution and provide water quality benefits.

Crop Production

Best Management Practices for the control of sediment from crop land also include those agricultural practices from which the C (ground cover and field management) and P (supporting practice) factors were developed for the Universal Soil Loss Equation. They involve measures ranging from management of surface and vegetative coverings and tillage to supporting soil and water conservation practices (See Figure 3-1). As water and wind action both cause erosion and transport of sediments, these processes must be considered in the design of control practices.

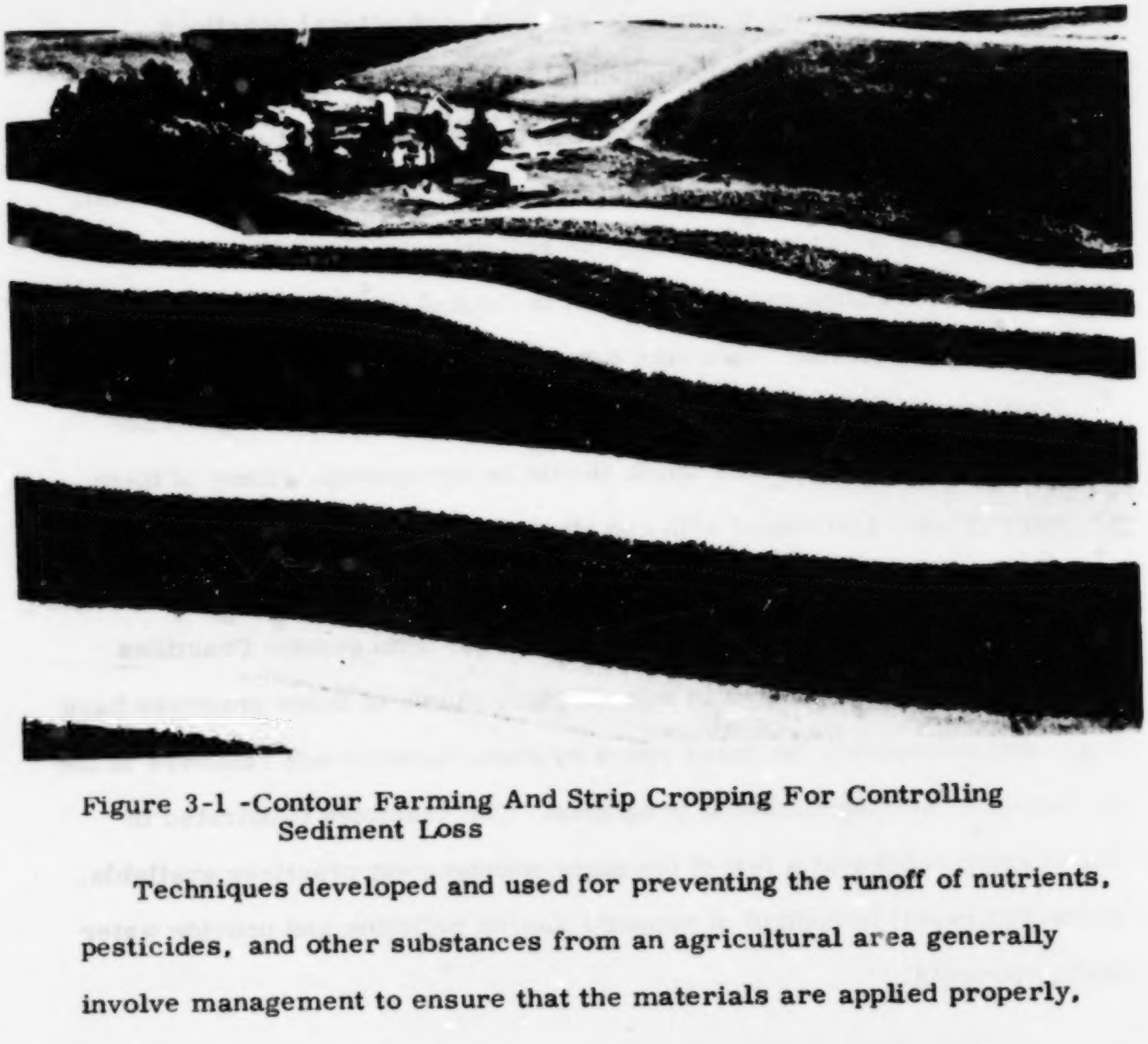


Figure 3-1 -Contour Farming And Strip Cropping For Controlling Sediment Loss

Techniques developed and used for preventing the runoff of nutrients, pesticides, and other substances from an agricultural area generally involve management to ensure that the materials are applied properly, only optimum dosage is used for target pests, timing of application is considered in accordance with use and runoff conditions, and disposal of unused pesticides and containers conducted in an approved manner.

Best Management Practices for agricultural activities must be developed, designed, and constructed, or provided, in accordance with local climatic, soils, vegetative, topographic, and other conditions to be fully effective for nonpoint source pollution control purposes. They should function independently and cooperatively to protect disturbed soils or other potential nonpoint sources of pollution from rainfall and runoff water, reduce the velocity and quantity of runoff, filter out sediments and other materials being transported, and detain runoff to cause deposition of sediment particles being transported by water or wind.

Erosion and Sediment Control

The major quantity of sediment results from erosion by water, a complex process. It is dependent upon natural factors such as climate, topography, and soil characteristics which, in general, are uncontrollable by man, as well as the production, tillage practices, and structural conservation measures which are subject to management decisions and control. Many control measures and techniques have been developed for preventing, or reducing,both the erosion and transport of sediments from an agricultural area. They vary from management of surface vegetative coverings and tillage to "structural" practices, or systems of practices.

Many practices useful for controlling, or preventing,the runoff of nonpoint sources of pollution from an agricultural site also function to reduce the peak flows and velocities of the runoff waters. Since stream channel erosion in downstream areas generally results from increased runoff flows caused by man's activities, this problem can be alleviated by the application of Best Management Practices.

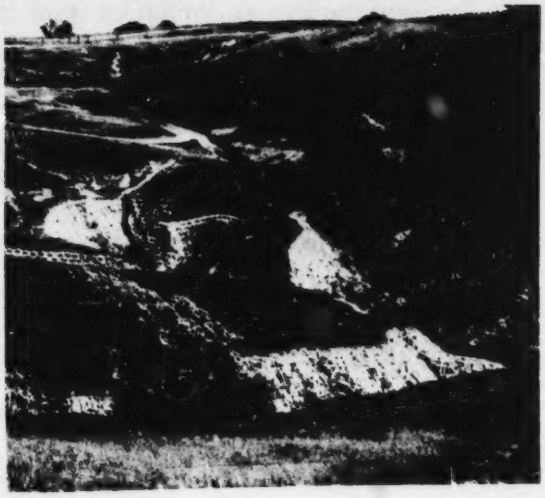


Figure 3-2 - Trees Planted on Gullied Area

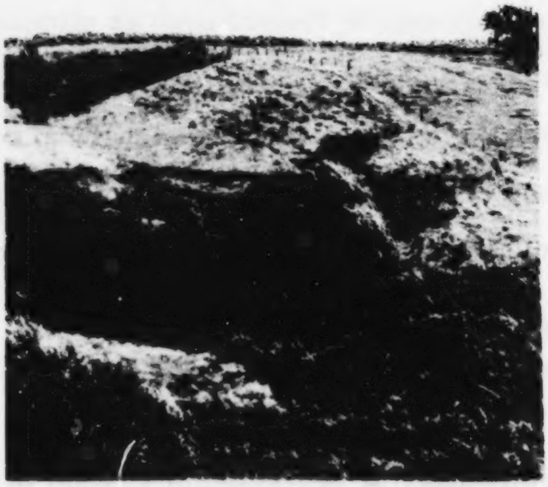


Figure 3-3 - The Same Scene Two Years Later AfterTrees and Grass Have Become Successfully Established

Surface Protecting Vegetation: Cover crops are grown for soil conservation purposes, when otherwise there would be no growing plants or residues to protect the soil surfaces from erosion, and to filter out moving sediments. One example is winter rye which is seeded shortly after a corn crop is harvested. Even though residue left from harvesting the corn provides some surface protection. the rye more adequately protects the soil during the fall, winter, and early spring when the field would otherwise be subject to erosion Many cover crops can be left on the soil to serve as a protective mulch, or be plowed under for soil improvement. They may be special crops planted specifically to provide protection or they may be crops typically found in the rotation but planted at a different time. In all cases, use of cover crops provides better protection from the erosion effects of rainfall and runoff than the continuous tilling crops. Trees, shrubs and grasses may be needed to handle severe erosion problems; and in critical areas, conditions may require a conversion of cropland to grass or trees (See Figure 3-2 and 3-3).

Strip cropping can effectively reduce the velocity of runoff water and provide surface soil protection against water or wind erosion. It involves the alternate arrangement of strips of close-growing crops or grasses between strips of tilled row crops (See Figure 3-4). The grasses and close-growing crops function as sediment filters, buffer strips, and other water control measures.

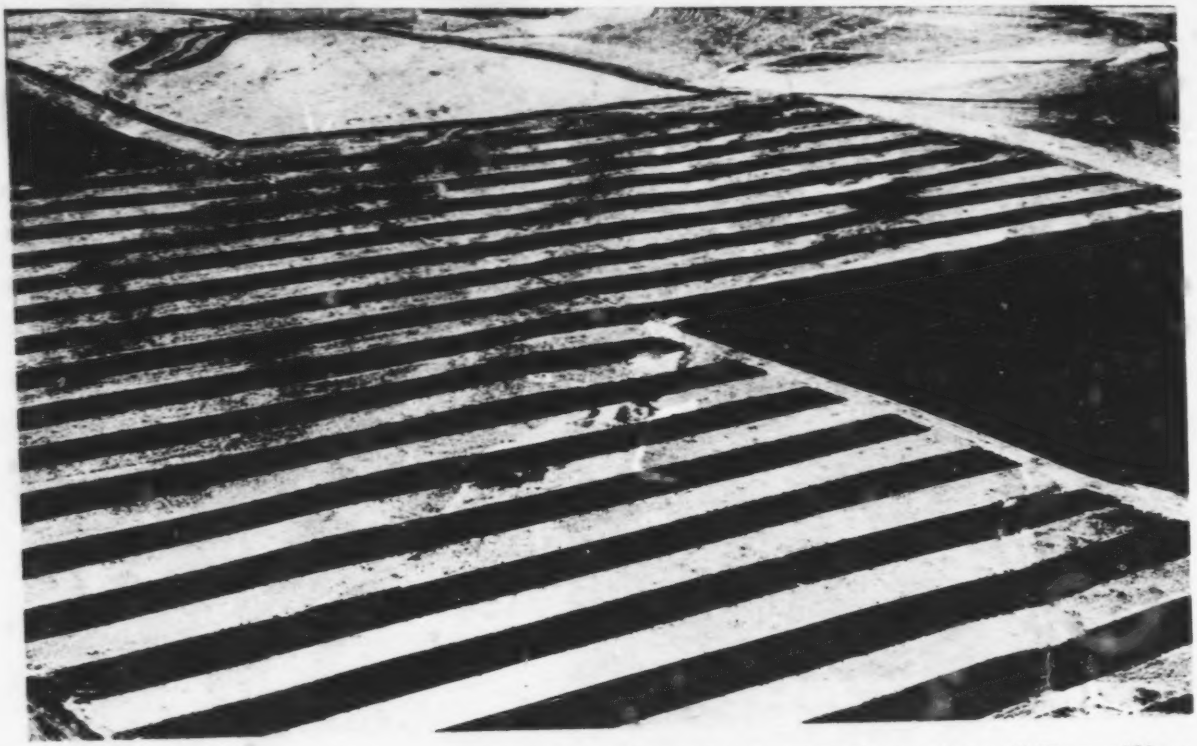


Figure 3-4 - Stripcrops Planted At Right Angles To Direction of Prevailing Winds to Stop Wind Erosion

The rotation of sod-forming grasses and legume crops with row crops which cause conditions that make the ground highly susceptible to erosion can be effective for reducing soil and nutrient losses in farmlands and in maintaining soil structure and tilth. Crop rotation also provides for both deep and shallow rooted plants which bind soil masses together to prevent erosion and improves its physical condition.

Tillage practices: Tillage which involves the turning, or disturbance of the soil for agricultural purposes probably generates the greatest potential for erosion of soils by both water and wind (Figures 3-5 and 3-6). A number of alternative tillage systems, developed during the last few years to reduce erosion, are identified under the following names--minimum tillage, mulch tillage, and conservation tillage.

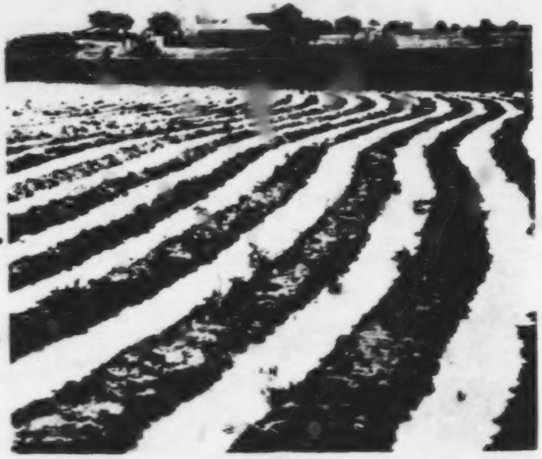


Figure 3-5 - Furrows Across The Slope Still Hold Water a Day After A 4-inch Rainfall.

Under some systems, a surface configuration is obtained that retains water to increase infiltration of runoff. Others result in residue being left on the ground surface from a previous crop to protect it from wind and water erosion. (Reference No. 3-1).

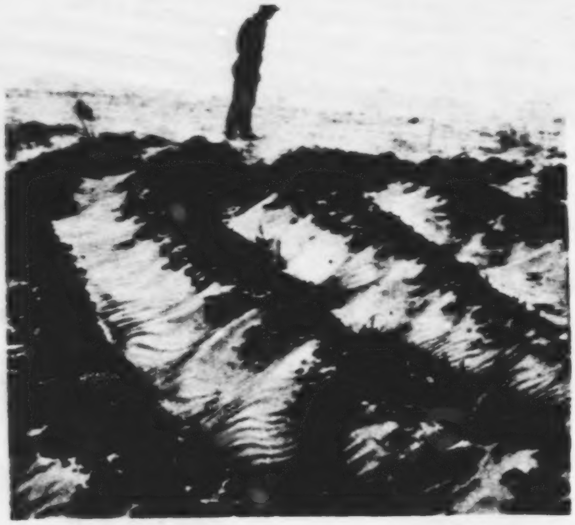


Figure 3-6 - Furrows Protecting Field From Wind Erosion and Collecting Sediment From Field in Background.

The conservation tillage system that best fits a farm operation must be developed in accordance with the crop types grown, soil characteristics, topography, and climate of the area. The following systems, if properly carried out in accordance with site conditions, can be effective in reducing erosion and the transport of sediments from a farm area:

1. No-tillage (Figure 3-7)-- This system uses a disk, or other device, to cut through the residue of the previous crop, ahead of the planter shoe. It leaves a maximum of residue cover to protect the soil and requires no seedbed preparation prior to tilling. Increased use of herbicides may be needed, however.
2. Ridge plant -- Planting is done on ridges of plowed soil year after year, with no seedbed preparation prior to planting. It is a good practice for reducing erosion in straight-row farming as runoff from rain must run down the ridge into residue collected in the furrow. Here, the soil is protected and the sediment entrapped.
3. Till-plant -- A narrow planter shoe opens a seed furrow into which seed is dropped as equipment clears a strip over an old row, places loose soil over the seed. Furrows must be oriented along the contour to reduce erosion.
4. Strip tillage -- A narrow strip is tilled and seed planted in the same operation. Soil between rows is undisturbed. This is an applicable technique when minor tillage in row zone is needed.
5. Sweep tillage -- Used to kill early fall or spring weeds in small grain stubble. The soil is shattered and lifted and the residue is left on the surface for protection. The shattered soil enhances infiltration of runoff.
6. Chisel planting -- A seed row is prepared by a narrow-blade chisel, with a planter immediately behind. Water and wind erosion is reduced as the surface roughness is increased and crop residue remains to protect the surface.
7. Listing -- Tillage equipment pushes soils into ridges between rows; and the seeds are planted into furrows in one total operation.

This must be done on the contour to conserve water and prevent soil losses.

8. Plow plant (Figure 3-8) -- Planting is done directly into plowed ground without secondary or following tillage. The large clods that develop restrict surface sealing and provide for increased infiltration of rainfall and runoff.

9. Wheel-track plant -- Planting is done in the wheel tracks of tractor or planter. Advantages are similar to that of plow-plant but not restricted to plowed ground.

10. Subsoiling -- This practice breaks up impervious subsurface "pans" in soils containing such layers. It increases the infiltration capacity to reduce runoff.

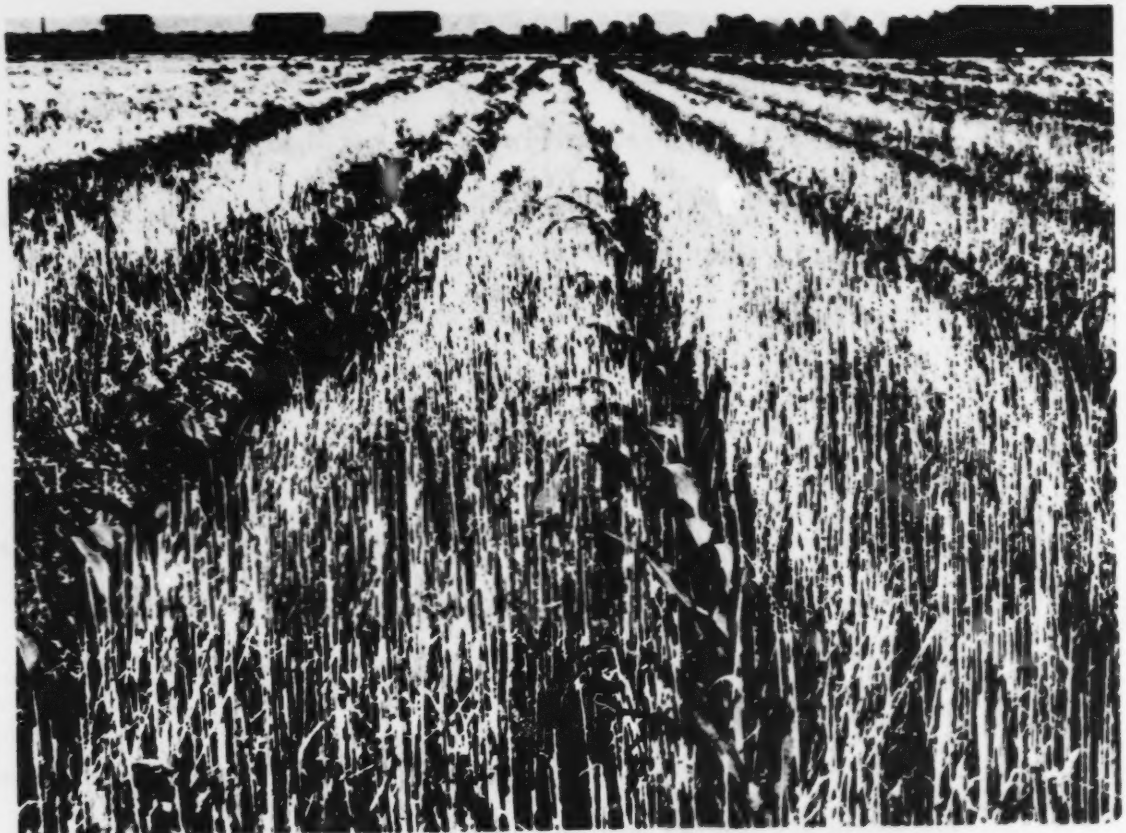


Figure 3-7 - No Till - Corn Plants Coming Through Wheat Stubble.

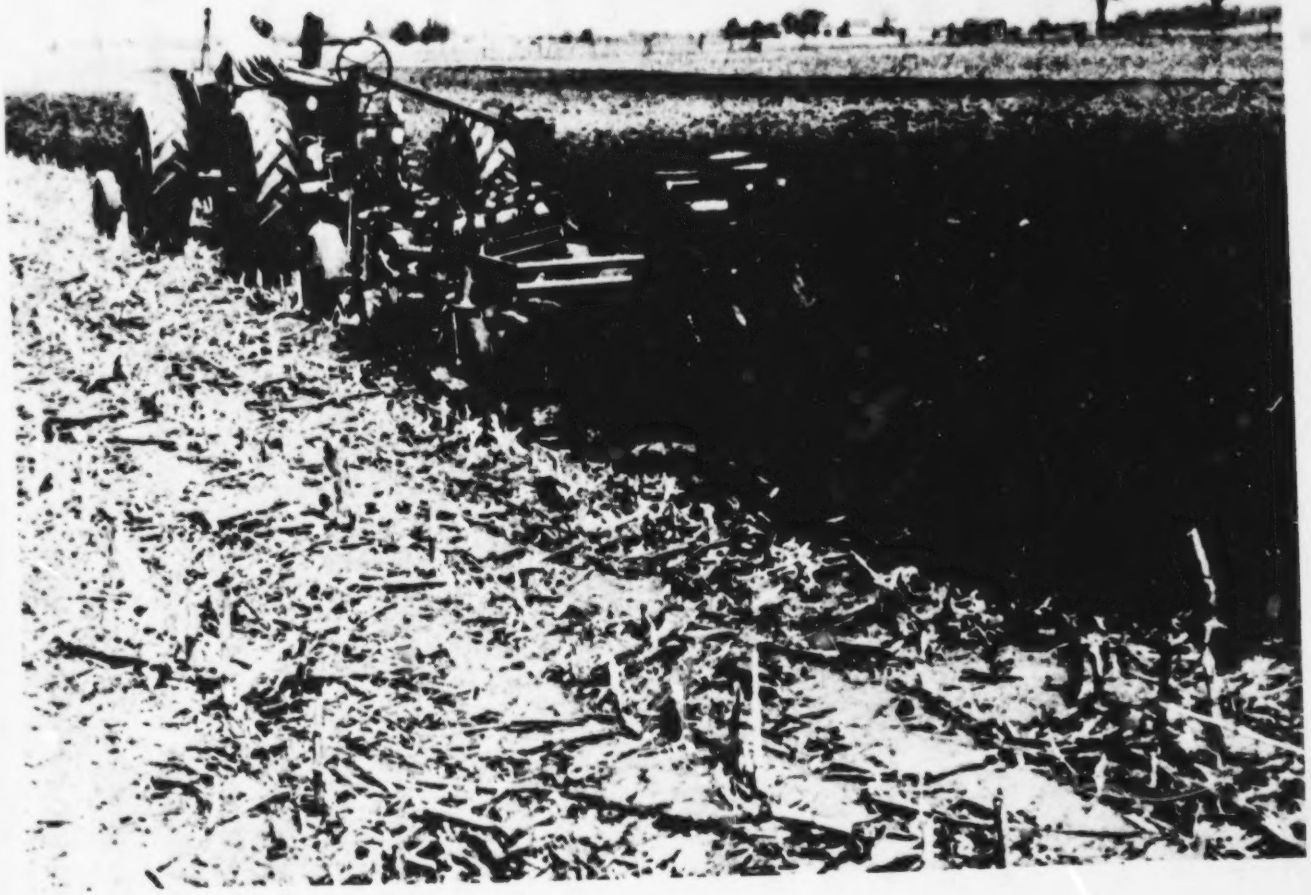


Figure 3-8 --Plow-planting

Timing field operations properly can greatly influence erosion and sediment losses from farm lands. Plowing or other soil disturbing activity should be minimized during times of great rainfall erosivity. This requires an understanding of times of the year when the erosion potential is greatest, types of crops useful during this time, and characteristics of soil materials subject to erosion.

Performing tillage operations on the contour, normal to the slope of the land, provides much more protection from water erosion than tilling parallel to the slope. Furrows can collect and hold large quantities of water during rainstorms and reduce the runoff velocity, thereby increasing infiltration and reducing erosion. Contour tilling practiced on gentle slopes, or in combination with stripcropping or terracing on moderate slopes, can effectively reduce erosion.

Structural Conservation Measures: Eliminating surface runoff will largely prevent sediment losses. Sediment will be generated by rainfall, and other activities but transportation of particles will not occur. Use of vegetative coverings and tillage practices will do much to control the runoff but additional measures are required in many cases to reduce its quantity and velocity. They are termed structural support practices and are classified as P factors in the soil loss equation. Included under the structural classification are terraces, grassed waterways and outlets, diversions, grade stabilization facilities, and water retention structures. They function to reduce the gradient of slopes or water courses through which runoff flows, decrease the velocity of running water, trap sediment, and reduce the peak runoff flow.

Additional guidance on the design, construction, and maintenance of structural conservation measures can be obtained from the Engineering Field Manual of the Soil Conservation Service (Reference No. 3-2) and from State Conservation agencies, as well as, from Local Soil Conservation Districts. Consulting agricultural engineering firms can also provide guidance on control measures.

1. Terraces - Terraces consist of earth embankments, or ridges and channels which are constructed across the slope of the land for the purpose of reducing the slope length and intercepting the flow of surface runoff (See Figures 3-9 and 3-10). They are constructed with a level channel and ridge in areas of low rainfall and pervious soils, to store water and provide infiltration. On less pervious soils, and where rainfall is greater, they may be graded to an outlet area and function as a diversion structure. For design, detailed consideration must be made of the rainfall and runoff quantities to be expected within particular time periods, soil characteristics, slope steepness, and type of cropping system used.

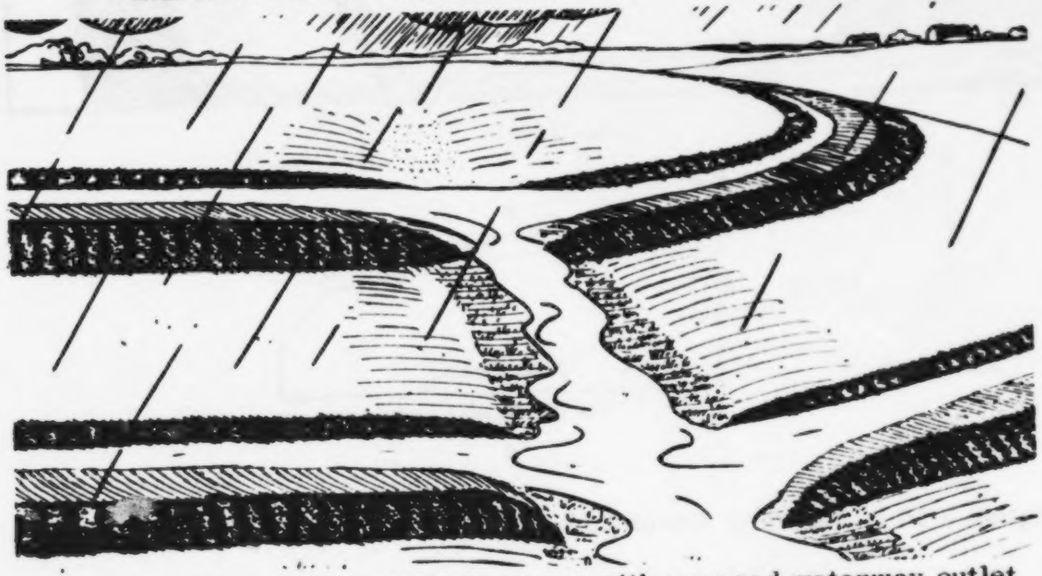


Figure 9 - Sketch of gradient terraces with grassed waterway outlet

Terraces are designed to reduce erosion by reducing slope lengths and promoting infiltration of runoff water. Discharge of surface water from a terrace must be conducted to a stable area or to a grassed waterway which will transmit it to a stable area at nonerosive velocities. Subsurface drains often are used to release outflow from terraces.

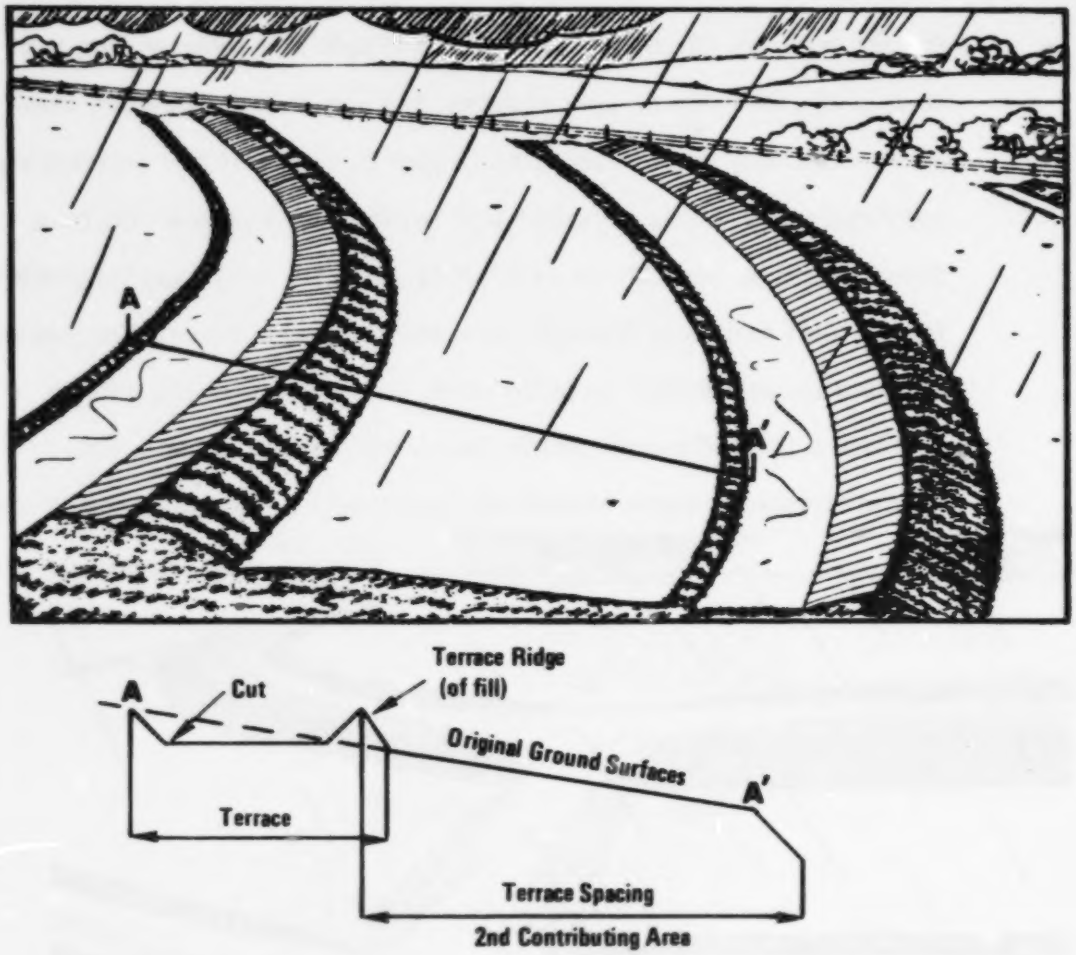

A
A'
Terrace Ridge
(of fill)
A
Cut
Original Ground Surfaces
A'
Terrace
Terrace Spacing
2nd Contributing Area

Figure 3-10 - Sketch of Level Terraces, With Cross Section

2. Grassed Waterways - These waterways are basic conservation measures and are being used for reducing erosion in farmlands. Consisting of natural, or constructed channels, protected with erosion-resistant grasses or other vegetation, they provide for the safe disposal of runoff water from terraces, diversions, and other structural measures (See Figure No. 3-11). Waterways subject to prolonged water flows may require additional structural controls such as grade control structures, provision of non-erosive center sections, and the like.

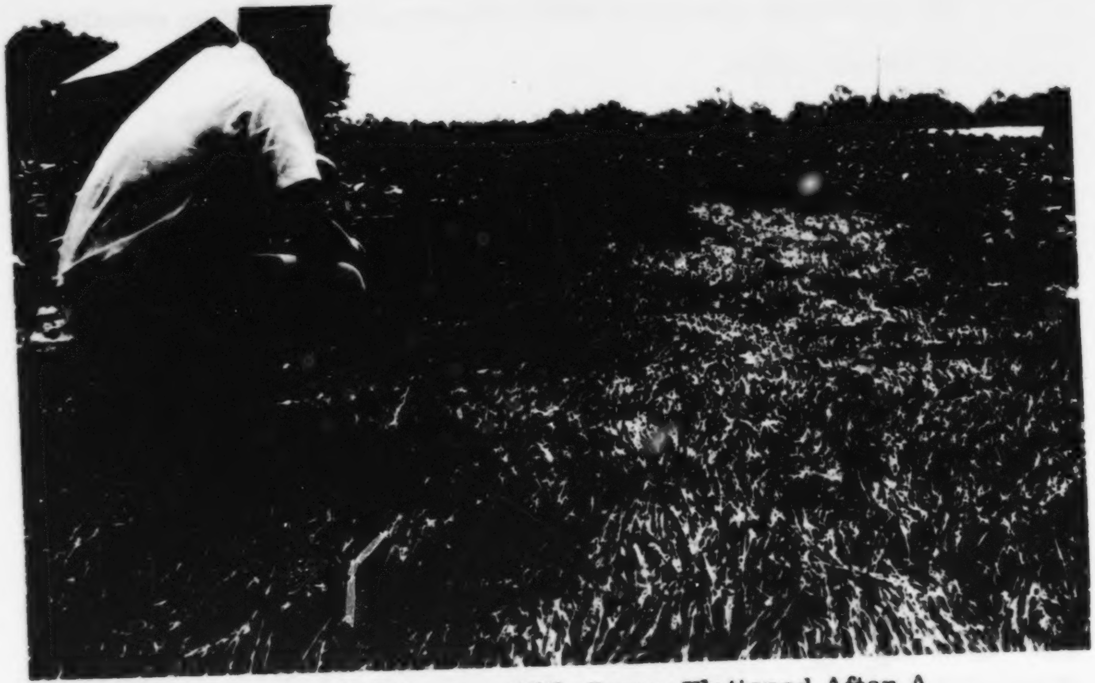


Figure 3-11 - Grassed Waterway With Grass Flattened After A Very Heavy Runoff Period

They must be constructed in advance of any structures that discharge into them and must be fully vegetated before receiving runoff flows. If possible, a natural channel should be used for a waterway, if vegetated sufficiently.

3. Diversions - Diversions are channels which are constructed, with a ridge formed of earth embankment on their lower sides, across a slope (See Figure 3-12). They are graded to discharge into grassed waterways or other erosion resistant outlets and discharge areas. Their principal uses for erosion and sediment control include protecting farmlands from excess runoff and sediment deposition, reducing the effective length of slopes to decrease runoff velocities, diverting water away from eroding areas where it is concentrating or into sediment detention structures, and providing support to other structural conservation practices in runoff control.

Figure 3-12 - Diversions Spreading Water to Reduce Gullying

In the location and design of a diversion, consideration should be made regarding expected quantities and peaks of runoff, the slope steepness and length, soil characteristics, and the uses of the land above the structure. Areas upslope from diversions should have erosion and sediment control practices applied to prevent excess sediment from accumulating in diversion channels and restricting their capacity to transmit water.

4. Grade control structures - These structures prevent erosion and grade changes in drainage channels and control the upslope migration of gullys. They are usually installed after a problem has been initiated and so must be considered remedial rather than preventive measures.

   Grade stabilization structures are located in areas where runoff has been concentrated and is erosive, so any portion subject to the runoff must be made of highly resistant materials such as wood, rock, concrete, wire mesh, brush, steel, etc. (See Figure 3-13). They reduce the velocity of flow in erodible channels to reduce erosion and they provide materials or structures that can withstand the higher erosive velocities.

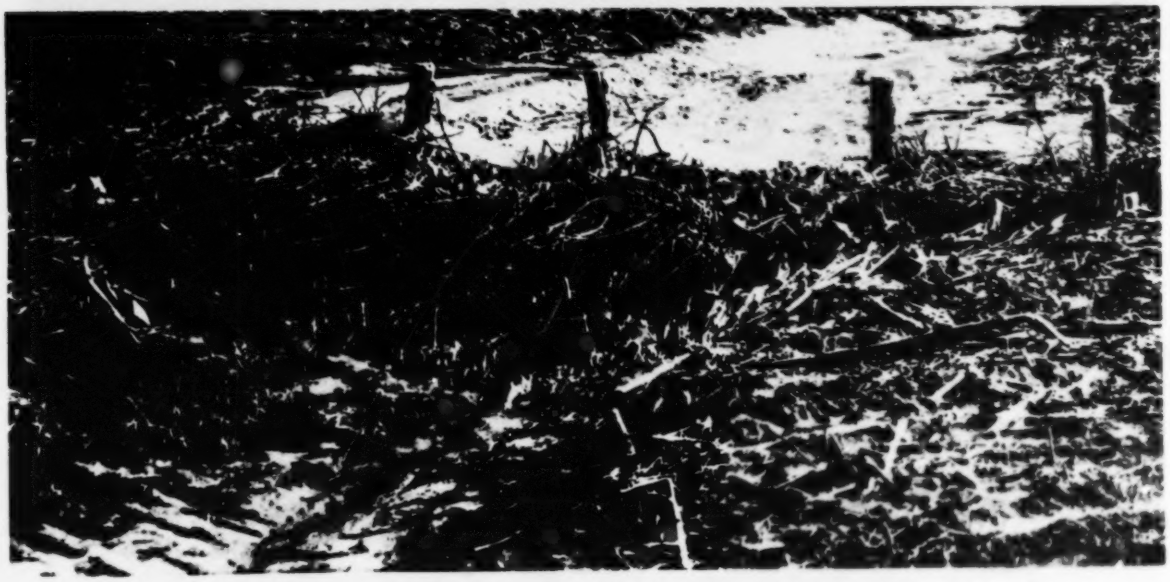


Figure 3-13 - Gully Controlled by Small Dams Until Vegetation Can Be Established.

5. Water and sediment detention facilities - In addition to trapping and detaining sediment eroded from the drainage area above, these multipurpose facilities can store water for support of fish production, animal watering, and recreational purposes. They can be created by the construction of an embankment across a water course or by excavating a required storage volume (See Figure 3-14). The latter type generally has limited storage capacity.

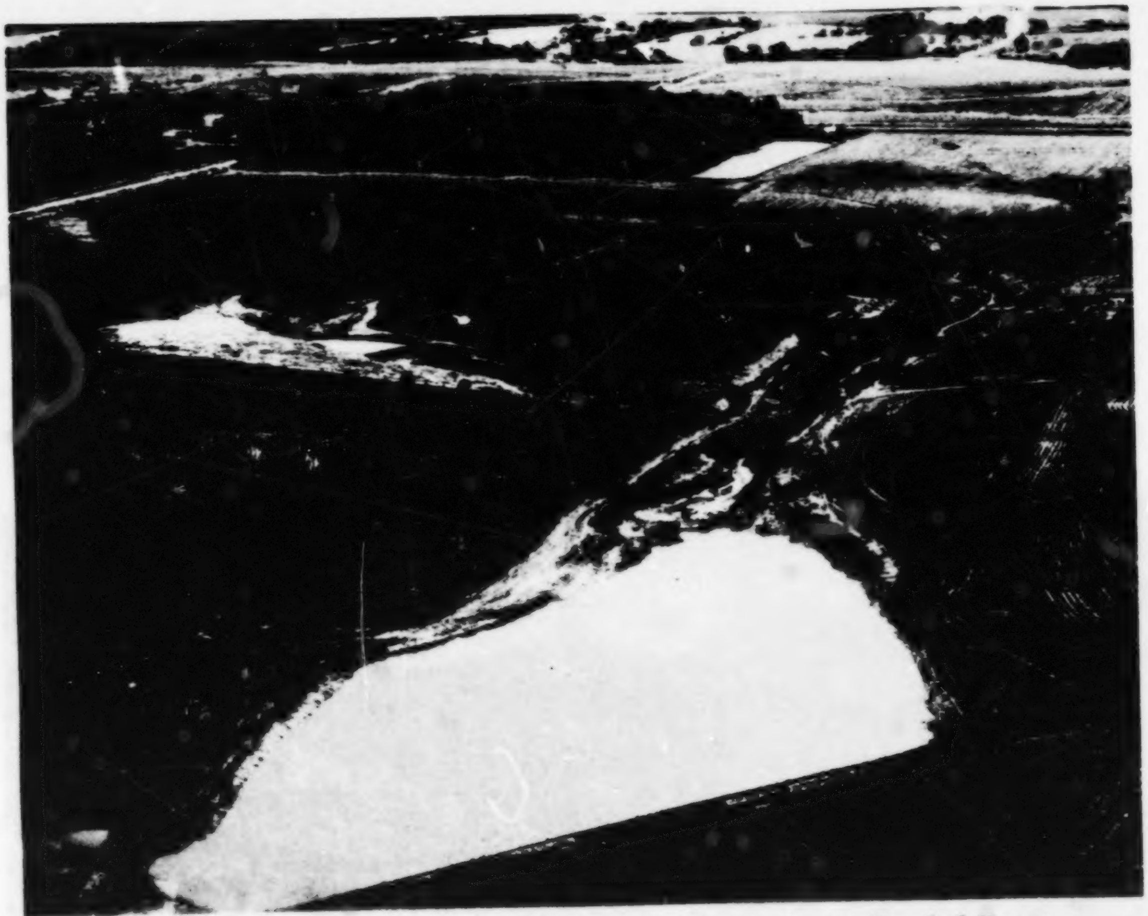


Figure 3-14 - Water Retention Structure Traps Sediment Eroded From Drainage Area Where Terraces, Contour Farming, and Grade Stabilization Structures Have Been Applied.

For effective sediment detention, the detention time must be long enough for sediment particles to settle to the bottom and be trapped. If material is fine-grained, such as clay, few farm reservoirs will be large enough to provide sufficient detention time. Reservoirs should also be designed to prevent the direct movement of sediment-laden currents from the head of reservoir to outlet.

Wind erosion occurs mainly in arid to semi-arid areas where temperatures, and thus evaporation rates, are high; distances are great enough, without obstructions, for winds to reach erosive velocities; and soils are loose with individual grains easily separable.

Good farming practices, such as maintaining an adequate vegetative covering, are important for preventing wind erosion. Minimizing tillage so that soils consist of stable and cohesive clods rather than small granular masses also is a useful technique. Clods, or soil aggregates, are broken down by tillage, weathering, abrasion, and animal or implement traffic. In areas where crops such as cotton or peanuts are grown on sandy soils, the seeding of rye in the growing crop a few weeks prior to the harvest, or just following the harvest, will protect the soil during the winter and early spring.

Any operation or activity which increases the roughness of the ground surface is a wind-control measure. It can consist of leaving vegetative matter on the surface, mixing residue in the soil, or by providing ridges and furrows through tilling operations (See Figure 3-6 and 3-15). Deep tillage of sandy soils to bring to the surface underlying more clayey soils which form clods also help reduce wind erosion. Stabilizing the soil surface is critical. Surface residues are highly effective in reducing both wind and water erosion.

Reducing the effective width or length of fields in the direction of prevailing winds is another very important wind erosion and sediment transport control practice. This can be done by strip cropping, alternating strips of crops that are highly resistant to wind erosion with strips of crops that are more susceptible. Strips must be oriented perpendicular to the wind direction to be effective. Installation of wind barriers consisting of trees, bushes, fences, rock walls, etc., can also be used to reduce the length of the field and so reduce the distance over which wind can blow to increase its velocity. Barriers act to cause deposition of sediment as well as reduce erosion. The effectiveness of wind barriers depends on the geometric configuration and porosity of the barrier, as well as, the wind direction and velocity.

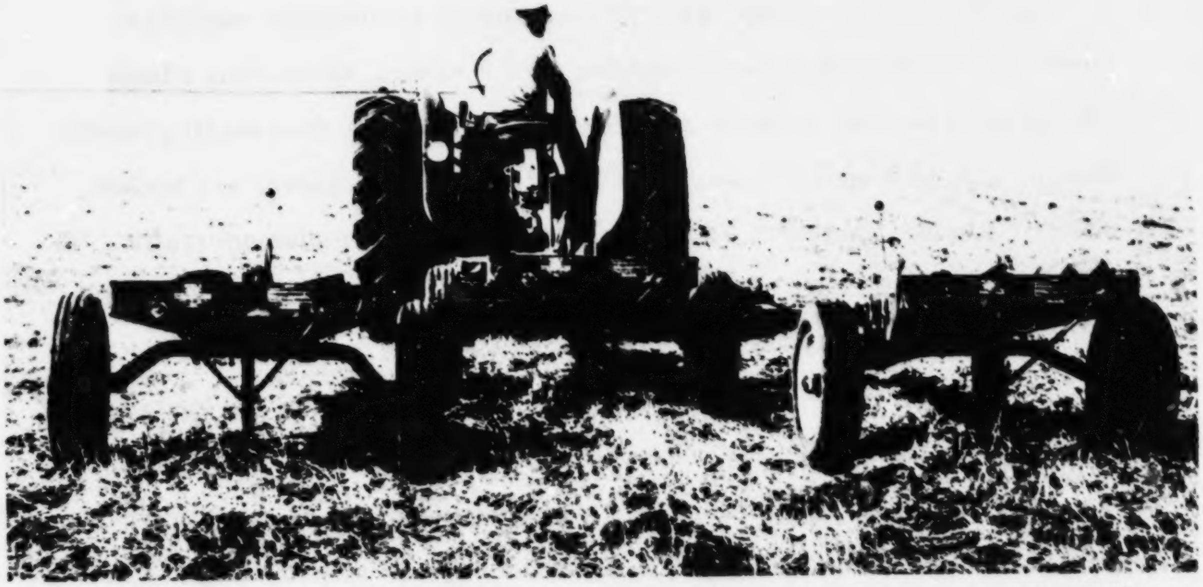
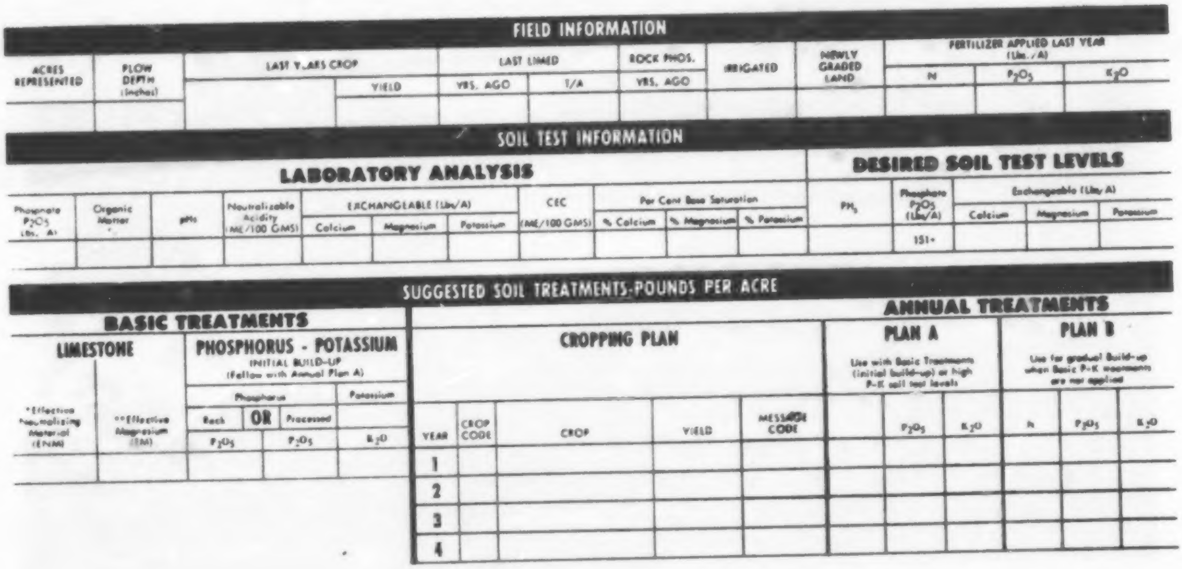


Figure 3-15 - Tillage Operation to Cut Roots of Weeds, Loosen The Soil, and Mix Organic Residues Into the Surface Soils to Control Wind Erosion

Information regarding wind erosion forces for use in developing BMP's for wind erosion control is available in the U. S. D. A., Agricultural Handbook No. 346 entitled "Wind Erosion Forces In The United States and Their Use In Predicting Soil Loss" (Reference No. 3-3). The information presented can be used for design and orientation of control measures.

Control of Nutrients

Best Management Practices with respect to nutrients applied for agricultural purposes must reflect the timing, type, and optimal quantity of nutrients applied, based upon soil tests and the agronomic demand (See Figure 3-16). The Cooperative Extension Service provides information and instructions for sampling fields for chemical soil testing. In most states, the Cooperative Extension Service and commercial (private) laboratories will conduct soil tests and recommend nutrient additions needed. In some states (two at present), all public soil testing is performed by commercial laboratories. Public testing laboratories are operated by universities, experiment stations, Cooperative Extension Services, and State Departments of Agriculture.



FIELD INFORMATION

ACRES REPRESENTED	PLOW DEPTH (inches)	LAST YEARS CROP		LAST LIMED		ROCK PHOS.	IRRIGATED	NEWLY GRADED LAND	FERTILIZER APPLIED LAST YEAR (Lbs./A)		
			YIELD	YRS. AGO	T/A	YRS. AGO			N	P_2O_5	K_2O

SOIL TEST INFORMATION

LABORATORY ANALYSIS											DESIRED SOIL TEST LEVELS				
Phosphate P_2O_5 (lbs. A)	Organic Matter	pHs	Neutralizable Acidity (ME/100 GMS)	EXCHANGEABLE (Lbs/A)			CEC (ME/100 GMS)	Per Cent Base Saturation			PHs	Phosphate P_2O_5 (Lbs/A)	Exchangeable (Lbs/A)		
				Calcium	Magnesium	Potassium		% Calcium	% Magnesium	% Potassium			Calcium	Magnesium	Potassium
												151+			

SUGGESTED SOIL TREATMENTS-POUNDS PER ACRE

BASIC TREATMENTS

LIMESTONE		PHOSPHORUS - POTASSIUM INITIAL BUILD-UP (Follow with Annual Plan A)		
		Phosphorus		Potassium
*Effective Neutralizing Material (ENM)	**Effective Magnesium (EM)	Rock	OR Processed	
		P_2O_5	P_2O_5	K_2O

ANNUAL TREATMENTS

CROPPING PLAN					PLAN A Use with Basic Treatments (initial build-up) or high P-K soil test levels			PLAN B Use for gradual Build-up when Basic P-K treatments are not applied		
YEAR	CROP CODE	CROP	YIELD	MESSAGE CODE		P_2O_5	K_2O	N	P_2O_5	K_2O
1										
2										
3										
4										

Figure 3-16 - Field Soil Test Information and Report and Interpretation Forms

Many nutrients can be controlled, or prevented from leaving a farm, through control of fine-grained sediments upon which they are adsorbed. Soluble nutrients such as nitrates, however, are not trapped with the sediment. They move with runoff or ground water (Reference No. 3-1).

It is fallacious to assume that all N applied will be utilized by a crop. Being soluble, considerable portions of it will escape the root zone of the plant. This especially depends upon the type, time and weather conditions during application.

The method of applying nutrients is an important control measure for there is a much greater pollution potential from surface applied nutrients than from nutrients incorporated into the soil during application (Figures 3-17 and 3-18). The methods of application, available must play a role in developing management practices.

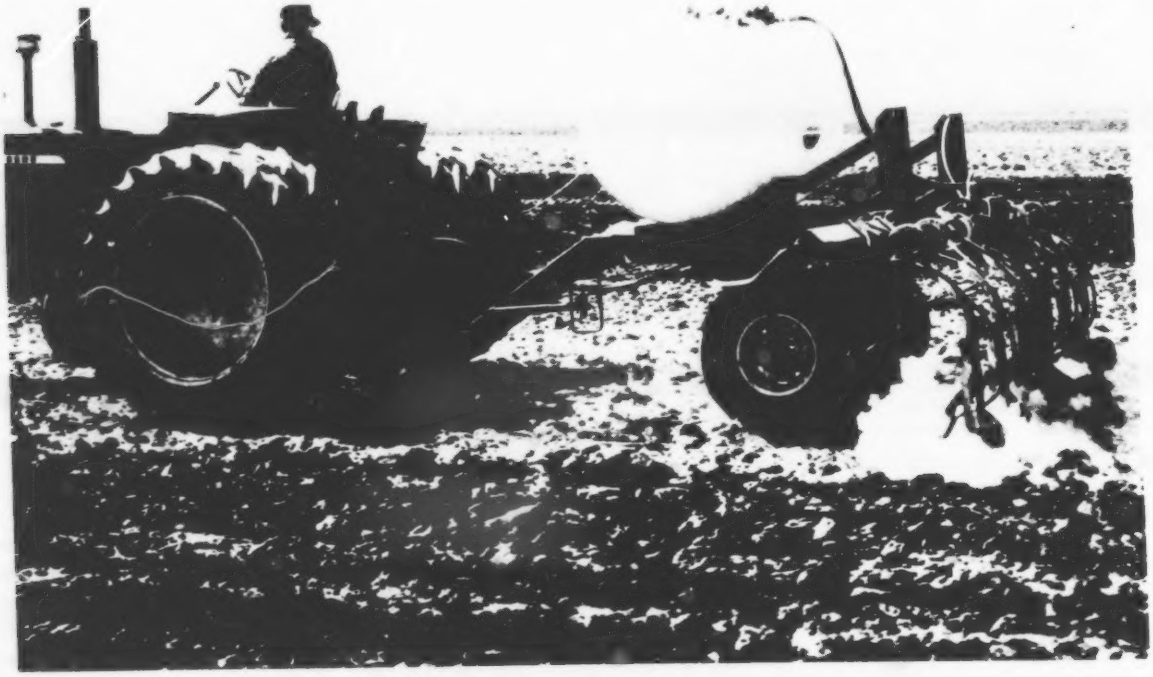


Figure 3-17 Poor Application of Anhydrous Ammonia, Shown By Escaping Gas. Proper Application, At A Depth of From 6 to 8 Inches Will Prevent Its Volatilization and Loss Into The Atmosphere

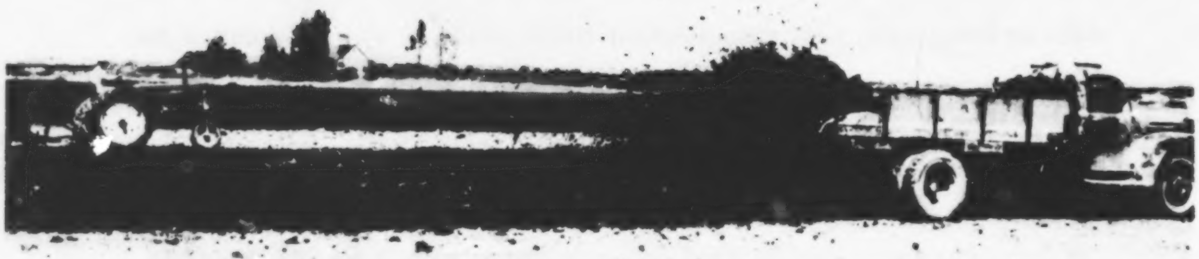


Figure 3-18 - Farmer Following Manure Spreader With Plow To Incorporate Manure Into The Soils

Alternating, or rotating crops which require little or no nitrogen from fertilizer, such as legumes, with crops which have large fertilizer requirements can substantially reduce the long-term average quantity of nitrogen which can be leached from the soils. Use of alfalfa, or other deep-rooted crops, such as winter wheat, to utilize the nitrates from deep zones can reduce the possibility of nitrates being leached and moving into ground or surface waters. Winter cover crops also can function to extract soil moisture, which contains nitrates, during the fall and spring seasons. This makes less quantities of the nitrates available to cause pollution (Reference No. 3-4).

Fertilizers should be applied to the land when the potential for intense precipitation and excess surface runoff is minimal. Slow release fertilizers can be used on very sandy soils. Application of manures or fertilizers to snow covered or frozen ground can be an extremely poor practice. When a thaw occurs, potential pollution problems may be created by nutrients and organic matter included in runoff.

Control of Pesticides

As with nutrients, best management practices for the control of pesticides must include a consideration of the timing, type, amount, and method of application. These practices can be used in conjunction with an integrated pest management (IPM) network which provides for the best combination of all available methods to manage and control all pests such as insects, weeds, diseases, nematodes, and rodents. At least 30 States have programs covering a variety of crops. The Cooperative Extension Service in corporation with EPA and the State is responsible for the IPM network.

Integrated pest management combines traditional methods such as crop rotation with measures using sophisticated insect traps and computer analyses of the life cycle of insects that show best how to interrupt it. The use of chemical poisons occurs only as a last resort. By keeping a tally of the numbers and types of pests present and matching that against computer analyses of their movement and mortality patterns, one can determine the balance of pests and their predators and which of the pests are likely to cause problems and when. In extreme cases the solution may be application of pesticides but more often there is an organic or other remedy.

As with nutrients, some pesticides adsorb to sediment particles and will be prevented from leaving the area of application through the use of effective sediment control measures. Additional control for these pesticides, and the soluble portions which move with the surface runoff and ground water must be achieved by requiring proper application procedures, reduction in the opportunity for accidental spillage, and proper disposal of containers as well as waste materials (Reference Nos. 3-1 and 3-4).

The use of pesticides for control of insects, fungi, weeds, rodents, and similar pests is restricted by Federal law; and State and local restrictions also may apply. Strict adherence to recommended practices is necessary to limit the possibility of these materials creating nonpoint source pollution problems. Application procedures should comply with registered label directions and the equipment cleaned in a proper manner after use, or disposed of properly (Reference Nos. 3-5 through 3-8, and Page 2-6 of this Guidance).

Pesticide volatilization can occur after pesticides have been applied or during application to possibly introduce pollutants into the environment (See Figure 3-17). Evaporation of the water portion of droplets can reduce their size and cause drift. Improper, inadequate, or careless disposal of used pesticide containers, equipment, or excess materials can result in pollution of surface or ground waters or can possibly kill nontarget terrestrial or aquatic life.

Application of pesticides immediately prior to periods of intense rainfall should be avoided as the runoff will transport the materials off the area of application. Aerial or other types of spray application should be restricted to periods of time and to areas where wind velocities are inadequate to cause drift of the materials. Periods of temperature inversion should also be avoided. Inversions result where air temperatures increase with altitude. A well developed inversion acts as a lid suppressing the vertical movement of air through it. Drift of the pesticides is related to pesticide particle or droplet, sizes, wind speeds, height of application, the existence of a temperature inversion, etc. Often, oils or emulsifiers are added to pesticides sprayed to increase the size of droplets and so reduce the drift hazard. The relationship between pesticide droplet and particle size and drift distance is indicated in Table 3-1.

Particle Type	Drop Diameter	Drift1/	
	Microns	Meters	Feet
Aircraft spray:			
Coarse	400	2.6	8.5
Medium	150	6.7	22
Fine	100	15	48
Air carrier sprays	50	54	178
Fine sprays and dusts	20	338	1,109
Usual dusts and aerosols	10	1,352	4,436
Aerosols	2	33,795	110,880

1/ Distance a particle would be carried by a 4.8 km/h (3 mph) wind while falling 3 meters (10 feet).

Table 3-1 - Drift Pattern in Relation to Spray Particle Size

Pesticide volatilization can occur after pesticides have been applied or during application to possibly introduce pollutants into the environment (See Figure 3-17). Evaporation of the water portion of droplets can reduce their size and cause drift. Improper, inadequate, or careless disposal of used pesticide containers, equipment, or excess materials can result in pollution of surface or ground waters or can possibly kill nontarget terrestrial or aquatic life.

Depth to ground water, direction of its movement, and subsurface hydrologic conditions must always be considered in underground disposal to prevent movement of waste materials into ground water. If pesticide-containing materials are burned, pollution may result through washout or fallout. Section 19 of the Federal Insecticide, Fungicide, and Rodenticide Act as amended in 1972 (Public Law 92-516) directs the Administrator of the Environmental Protection Agency to issue procedures and regulations governing the disposal of pesticide containers. Implementing regulations were published on May 23, 1973 (40 CRF, Part 165). Further dissemination of these regulations, and continuing education on the problems of incorrect disposal and on the dangers of accidental poisoning, can lead to a reduction in pollution from these sources.

Short lived or nonpersistent pesticides are environmentally preferable and should be used where ever possible. Alternatives to pesticides should always receive strong consideration. They can involve mechanical measures (tillage practices to remove materials available to nourish pests), biological controls (fungus coated seeds or predator insects), insect sterilization (releasing large numbers of sterilized male insects to fertilize females), insect toxins (use of naturally-occurring substances to poison pests), insect attractants (such as concentrated insect sexual attractant hormones), and development of disease-resistant crops.

Irrigated Crop Production

Erosion and sediment control practices for use in nonirrigated crop production are also applicable to irrigated agricultural areas during periods when irrigation water is not being applied and sediment losses are due to rainfall and surface runoff and possibly wind erosion. Some modification of these measures, particularly structural ones, may be required to comply with changes in topography or in differences in operation activities. Nutrients and pesticide control practices also are applicable to irrigated crop production.

The principal difference between irrigated and nonirrigated crop production nonpoint source pollution control involve the excess salinities and erosion and sediment runoff caused by the application of supplemental water. The natural salt content of applied water increases due to evaporation and transpiration processes (use by plants). Leaching of soluble salts from soils and underlying geologic materials results in the introduction of additional salts. Nonpoint source pollution control BMP's must consider these processes to prevent or reduce nonpoint source pollution from salts.

During periods of low rainfall, when natural erosion and other processes are almost inoperative, application of supplemental water for irrigation purposes can cause erosion and runoff of sediments. Control of sediments during this time must be designed in accordance with hydraulic conditions caused by the flow of applied water.

Salinity Control

It is almost impossible to prevent some degradation of water quality when irrigation of cropland continues for periods of time (Reference No. 3-9). Even if salt loading (the addition of dissolved salts to water from both natural and manmade sources) is prevented, the evapotranspiration process, which extract nearly pure water from the soil solutions. would cause salt concentrations. Control of irrigation return flow, however, is essential and so measures must be developed to minimize both the addition of salts and the concentrating effects of evapotranspiration.

Research is being conducted which indicate that salinity control may be accomplished partly by improving the presently-used irrigation and drainage practices (Reference No. 3-10). The basic philosophy behind the work is that the soil profile above the ground water body can be used as a salt storage reservoir. By proper irrigation management, the salt may be held indefinitely until released by leaching with excess water. Some studies indicate that very small leaching fractions (as small as 1-3%) can be used over long periods of time without the accumulated salts affecting crop yields. Under certain conditions, these studies suggest that salt may be precipitated out and stored within the soil layers without significantly creating adverse effects on farming operations. Research studies involve small areas under controlled conditions however. Extreme caution must be used before concluding that the necessary small leaching fractions can be feasibly achieved on a commercial scale.

Reducing Seepage Losses, Delivery Systems: Water conveyance channels, beginning with major canals which convey water from diversion facilities, or wells, to irrigation districts and farm systems and terminating in lateral distribution networks, in many areas are inefficient and so have excess water loss from seepage. This water loss from main delivery systems can be as high as 70% in some areas. After delivery of the water to a farm, 30-40% of the water can be lost from on-farm ditches and from inefficient crop production activities. The water lost may either be consumed by non-agricultural vegetation, evaporate into the atmosphere, or move into ground or surface water bodies. In all cases, its salinity increases due to the concentrating effects of evapotranspiration and the leaching of minerals from soils and other materials.

If these unnecessary losses of water can be prevented, or reduced, water pollution by salinity can be reduced.

Reduction in water losses from conveyance facilities can be accomplished by providing impervious linings to canals or by using pipelines for conveyance. Relatively impervious canal linings may be formed of compacted clayey soils, some type of asphalt or concrete, or plastic membranes. (Figures 3-19 and 3-20). Lining should be incorporated into all irrigation project distribution systems unless natural soils are so impervious that water losses are insignificant. It is a proven, effective deterrent to irrigation water quality deterioration (Reference No. 3-11).

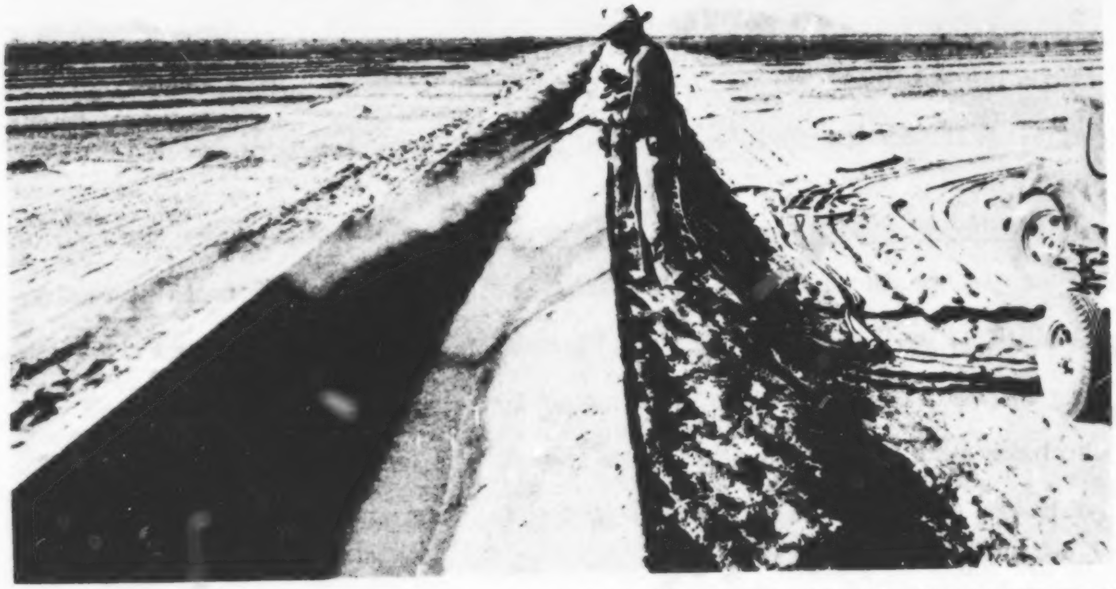


Figure 3-19 - Water Conveyance Ditch Being Lined with Air-blown Concrete.

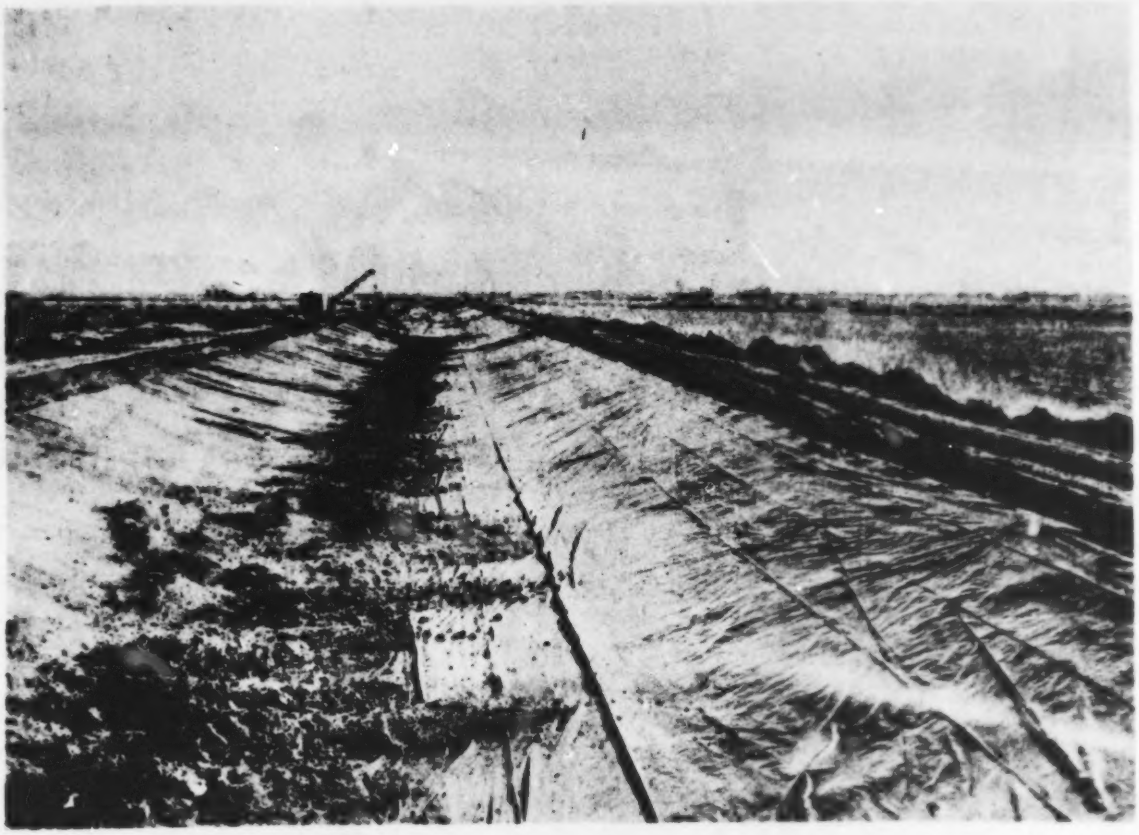


Figure 3-20 - Large Conveyance Channel Being Lined with Plastic.

A problem inherent in an open ditch, or canal, involves evaporation from the free water surface. This can be resolved by using pipe conveyances composed of steel, concrete or plastics. Pipelines not only eliminate evaporation and seepage losses, they provide better flow control regulation and usually occupy less surface area (Reference No. 3-11). Figure 3-21 shows a pipeline under construction.

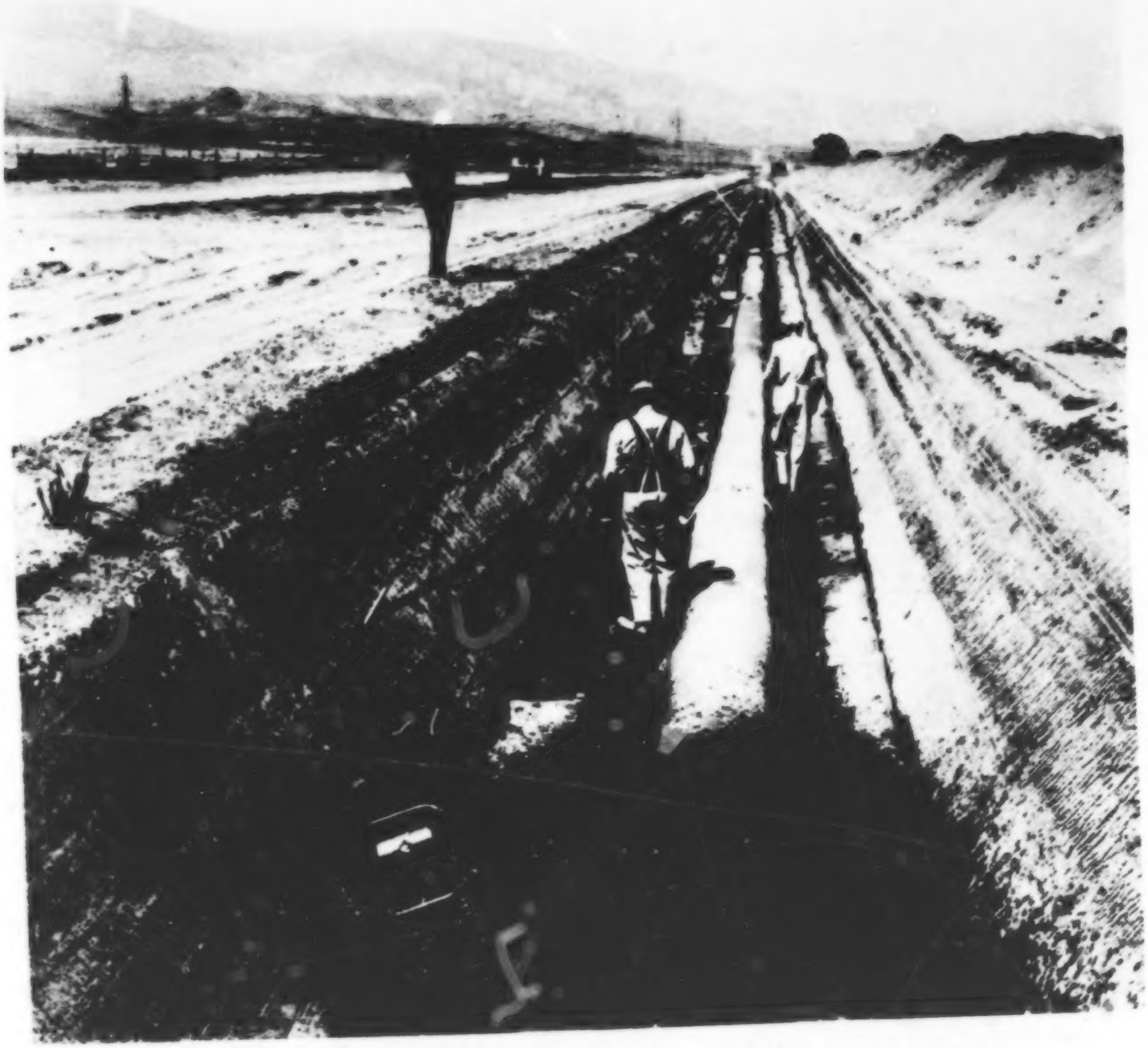


Figure 2-21 - Installation of 30-inch Diameter Pipe for Irrigation Distribution System.

Lining Terminal Storage Facilities: Irrigation storage reservoirs often are used to "firm up" water supplies. They provide adequate quantities of water during periods when irrigation demands exceed the rates of water being supplied. For example, low productivity wells can supply water continuously to a reservoir while the latter is used intermittently to irrigate at a rate greater than the wells can supply. These reservoirs may be excavated, partially excavated and formed of embankment materials, or constructed by placing an embankment across a watercourse. (See Figure 3-22).

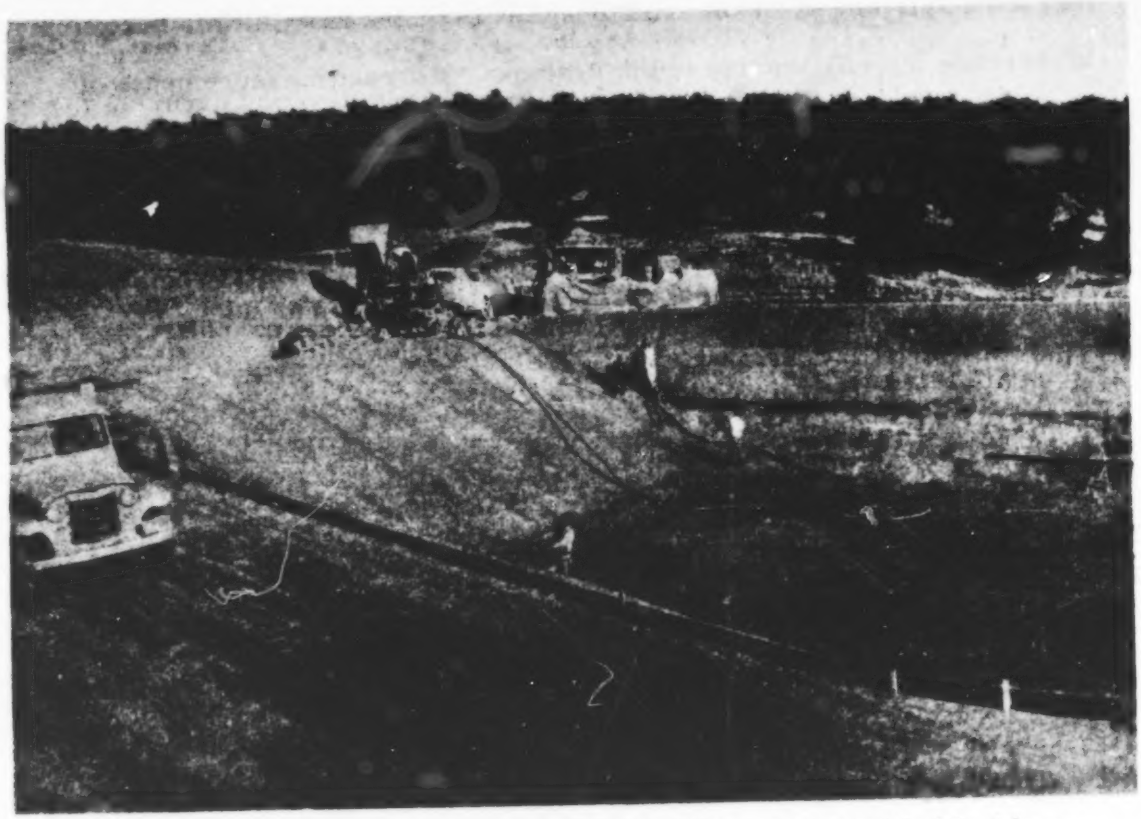


Figure 3-22 - Irrigation Storage Reservoir Being Lined With Air-blown Concrete. Sealing The Walls and Floor of The Structure Virtually Eliminates Seepage Losses.

Unless the storage facilities are situated in or on impervious ground, they will be sources of seepage. This loss of water, and subsequent leaching problems, can be prevented by lining the reservoir with a blanket, or layer, of impervious materials. As in the delivery systems these impervious materials can consist of compacted earth fill, concrete, asphalt, or plastic. Detailed suggested lining materials and methods of application are provided by the U. S. Agricultural Research Service, Soil Conservation Service and the Bureau of Reclamation. (Reference Nos. 3-12 through 3-14).

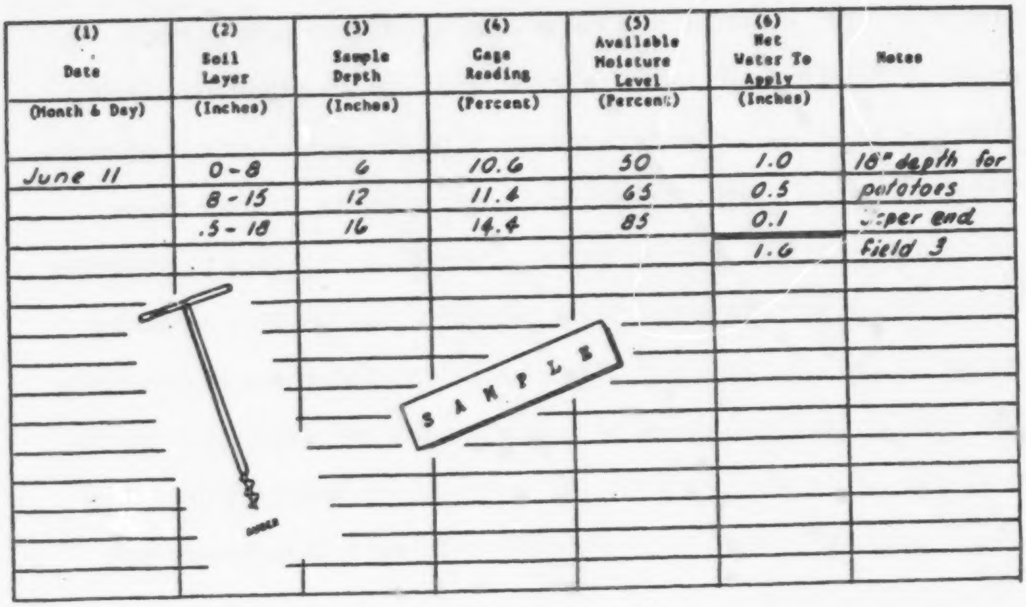
Increasing the irrigator's awareness of the quantities of water being lost from delivery systems and storage reservoirs may initiate his action to increase the efficiencies of his systems. Correct measurements of quantities of water being supplied to a system and the quantities leaving the system are required for sound water management. They will indicate where losses are occurring, their magnitude, and possibly what problems result. At present, few systems contain provision for metering or regulating the amounts of water at principal delivery points.

Proper Irrigation Water Management: Optimizing the quantity of irrigation water applied and the frequency of application will do much to reduce the salt concentrations and loadings in irrigation return flows. Presently used irrigation methods and State water rights, particularly in the semi-arid West, promote the widespread use of excess quantities of water which, in some cases, are detrimental to optimum crop yields. If only the quantity of water required to meet leaching needs and to satisfy plant intakes were applied, less additional leaching and movement of salts from soils would occur and more good quality water would remain in receiving streams or ground water reservoirs to dilute salt loads resulting from the water use by the plant species (Reference No. 3-15).

Controlled application of irrigation water through proper scheduling will result in reduction of excess seepage losses and surface runoff while still maintaining the correct moisture content in the soil root zone area.

Proper irrigation scheduling involves a process for applying only the optimum quantity of water to a particular crop when it is needed. In many areas a field is irrigated when it is dry rather than attempting to maintain an optimum level of moisture in the soil. Over application of water on an intermittent basis is done frequently. It may cause possible crop damage, excess surface runoff, or the deep percolation of water. Some studies in the western States indicate that irrigation efficiencies are less than 50%. Over application of water is occurring due to poor irrigation management and because the water may not be available in the future. As a result, water is not being applied when plants require it. Essentially, the reservoirs of soil moisture are not being fully utilized.

On-farm irrigation water management practices can be so sophisticated as to require computers for scheduling the application of water. Less sophisticated practices can be applied by the irrigator to reduce water losses and the quantities of irrigation return flows. They include determining the available soil moisture and related organic demands as a guide for water application, preventing overflow from ditches and laterals, improving the distribution of water over a field by eliminating irregular elevation differences, providing contoured terraces to prevent runoff; and selecting prudent irrigation methods (Figure 3-23 and 3-24). Substantial reductions can be achieved in the quantity of water applied by leveling, or releveling the land to obtain a more favorable configuration. As much as 40 to 50% reduction may result after leveling and the installation of a simple water measuring device (Reference No. 3-11).


SAMPLE
AUGER

(1) Date (Month & Day)	(2) Soil Layer (Inches)	(3) Sample Depth (Inches)	(4) Gage Reading (Percent)	(5) Available Moisture Level (Percent)	(6) Net Water To Apply (Inches)	Notes
June 11	0 - 8	6	10.6	50	1.0	18" depth for
	8 - 15	12	11.4	65	0.5	potatoes
	.5 - 18	16	14.4	85	0.1	Upper end
					1.6	field 3

Figure 3-23 - Field Moisture Check Sheet and Soil Auger for Obtaining Samples.

The U.S. Bureau of Reclamation, Cooperative Extension Service, and Soil Conservation Service, as well as private consulting firms, have available irrigation water management services and useful information for increasing the efficiencies of irrigation practices.

Surface irrigation and sprinkler systems comprise the two principal basic methods of applying water to croplands. Selection of the method to be used depends upon the topographic conditions, soils characteristics, quality of water available, plant tolerance and water requirements, climatic conditions, and similar local variables. Surface irrigation involves the direct application of water to the topographically higher area of a field from which it moves by gravity flow, to lower areas. Distribution of the water is dependent upon natural flow. It can involve flooding of an entire field or just directing the flow of water down furrows between rows

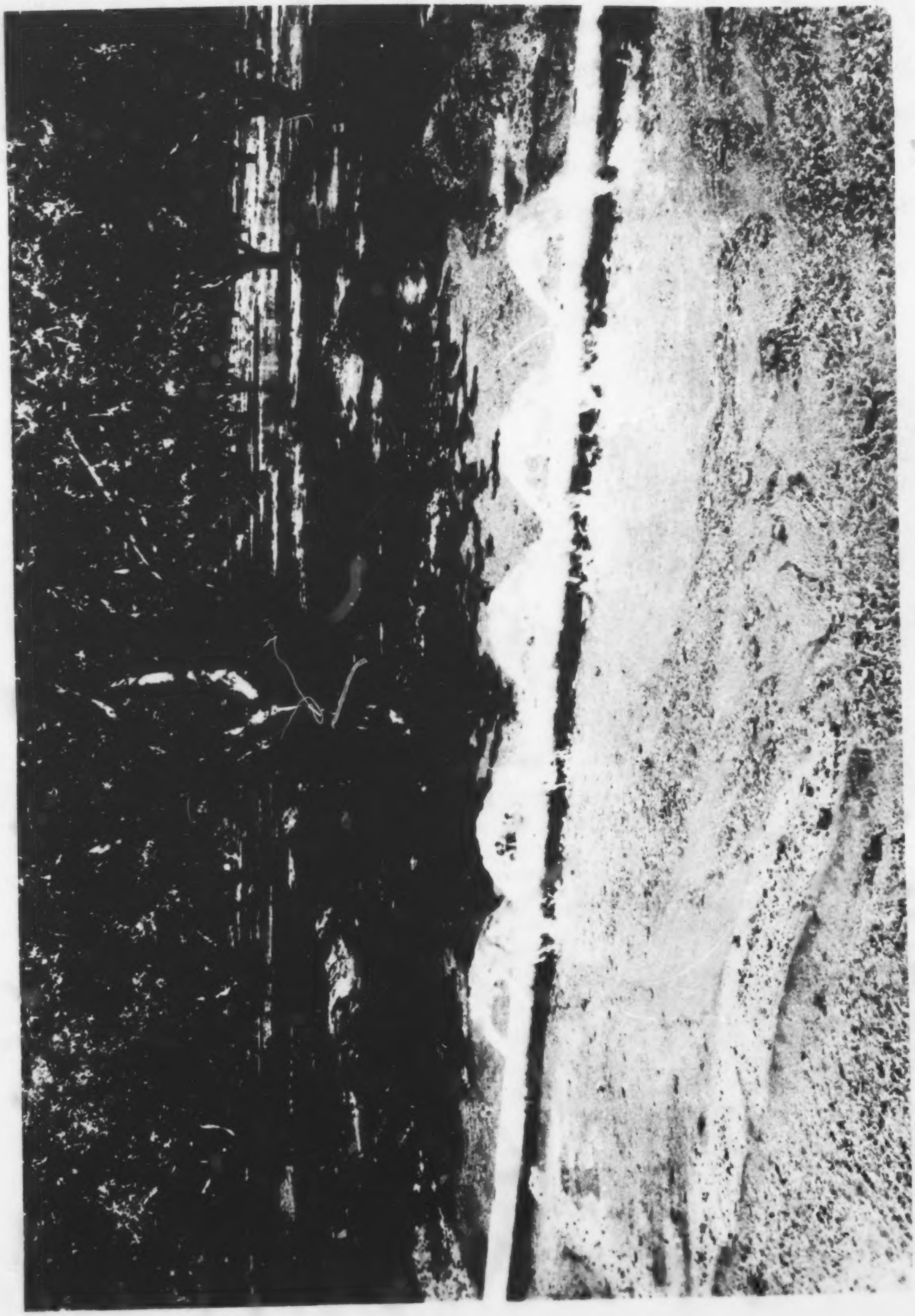


Figure 3-24 - Surface Irrigation of An Orchard

of crops (Figure 3-24). Excessive or rapid application of water should be prevented as it may result in excessive water losses and the resultant leaching of salts from the soils or cause severe erosion problems.

A fairly new modification of the surface application method is termed trickle or drip irrigation (Figure 3-25). This type of irrigation, as the name

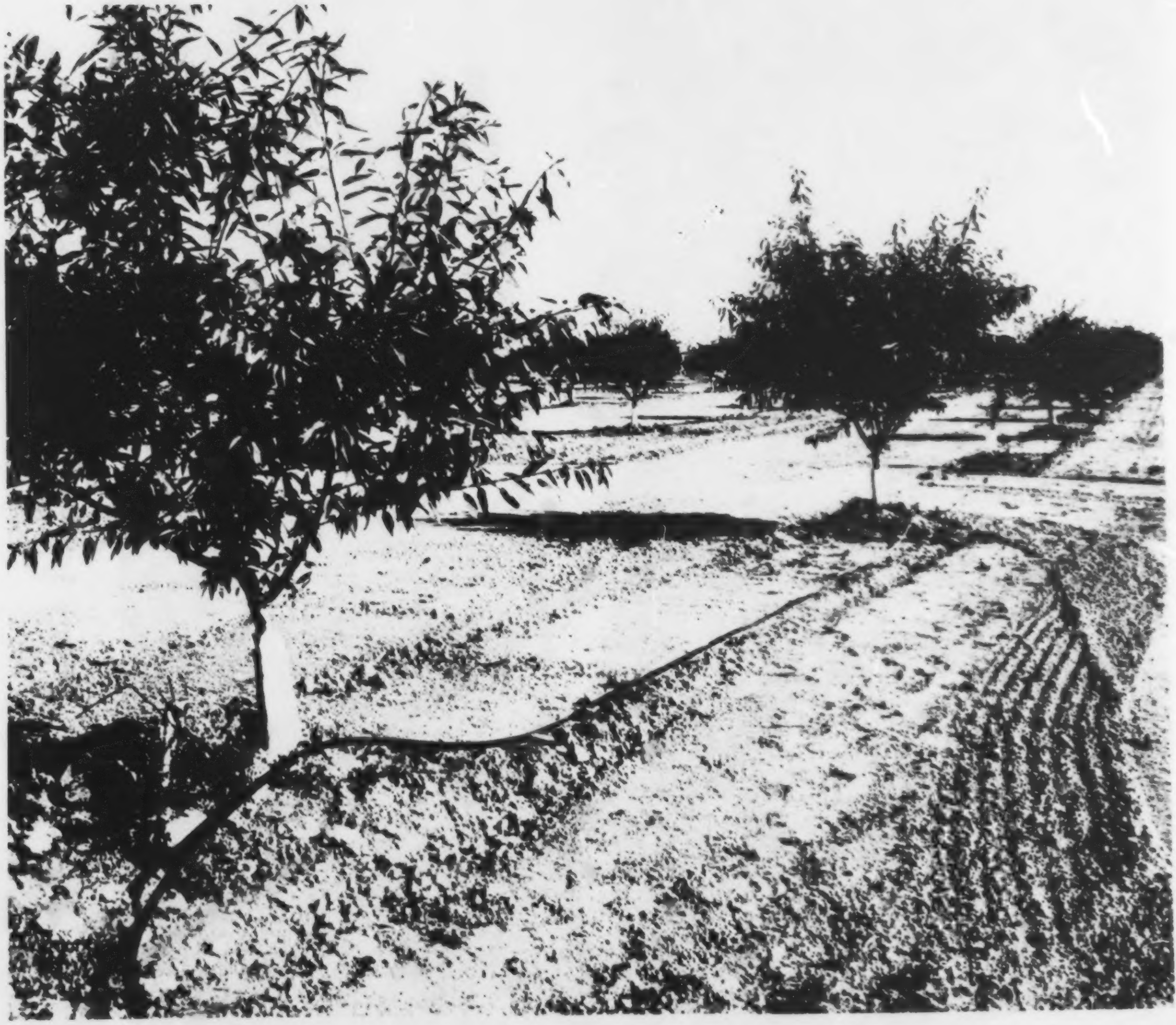


Figure 3-25 - Young Almond Orchard Being Irrigated by Drip Irrigation System

implies, results in the application of minor flows of water closely adjacent to the root zone of the crops. Application of water can be done from surface pipe systems or from pipes buried at shallow depths in the root zone. Compared with most other irrigation systems, drip and trickle irrigation wastes much less water and so evaporation is reduced, leaching minimized, and return flows of applied water decreased. Since there can be problems resulting from this type of irrigation method as well as benefits; proper management will involve a consideration of all alternatives prior to its use. Information on some advantages and disadvantages of drip and trickle irrigation are presented in Reference No. 3-16).

The sprinkler method can be used on lands of irregular topography and on many types of soils (Figure 3-26). Application of water is similar to the way it is naturally applied in that a uniform distribution can be made over the entire field. In contrast to nature's rainfall, however, sprinkler irrigation can be controlled so that only an optimum amount of water is applied at a selected rate. Excess runoff can be prevented and so salt loading, leaching and possibly erosion are reduced. The sprinkler method of irrigation is extremely flexible in operation and can even be used to apply selected quantities of fertilizers or pesticides to crops.

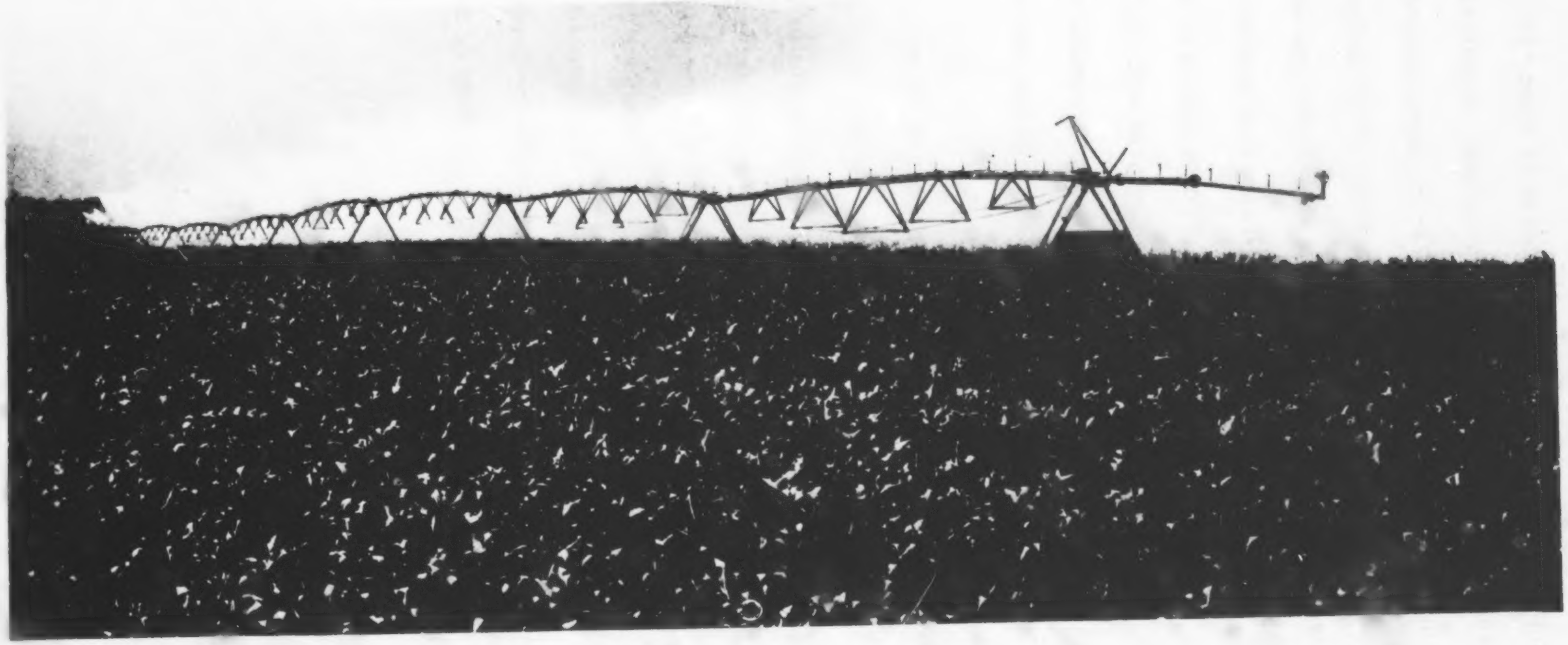


Figure 3-26 - Sprinkler System Supplied By Well Yielding 800 Gallons Per Minute

Controlling Sediment and Other Pollutants

The principles for controlling sediments, pesticides, nutrients and other pollutants resulting from non-irrigated crop production activities also apply to irrigated agriculture. For erosion and sediment control they involve vegetative coverings for soils subject to erosion, reducing the velocities of flowing water so that erosion and sediment transport is prevented, and trapping sediments that have been eroded and are being transported from the agricultural area in detention ponds or pits.

Providing non-erodible impervious linings for open water distribution channels and storage or detention facilities; locating grade-control, check dam structures where possible erosion may occur; and limiting the quantity and rate of surface water application to reduce runoff and prevent erosion are Best Management Practices for reducing and preventing erosion and sediment losses from irrigation. Lining provides structural stability to irrigation channels; prevents failure of side slopes, and eliminates erosion by high-velocity flows. Grade control and other erosion prevention structures maintain the hydraulic gradient of the channel section and prevent headward (up-slope) erosion and subsequent sediment losses (Figure 3-27). Judicious management of applied water reduces unnecessary runoff and possible erosion (Figure 3-28, 29, and 30).

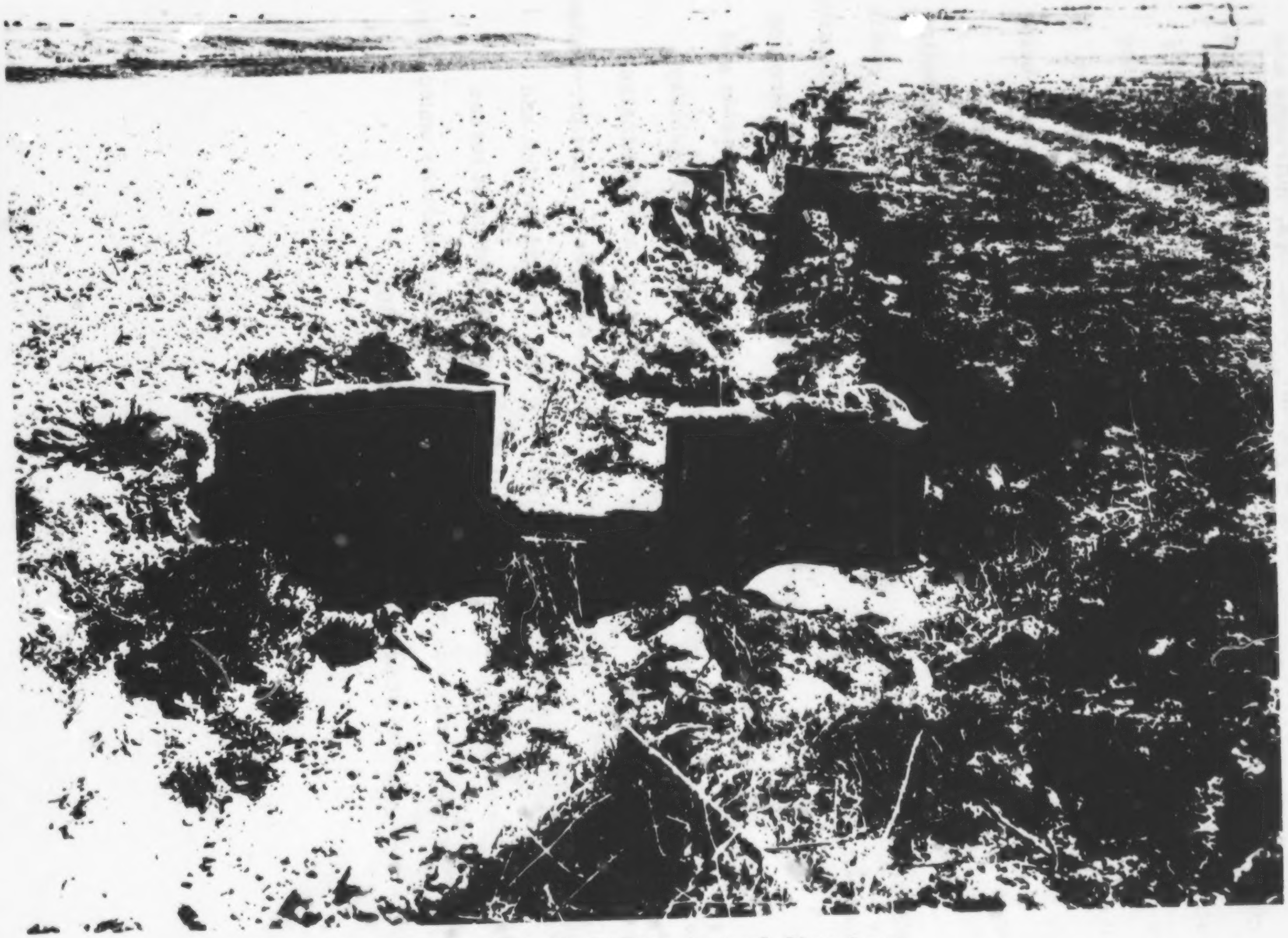


Figure 3-27 - Poorly-installed Water Control Structure Allowed Erosion to Occur

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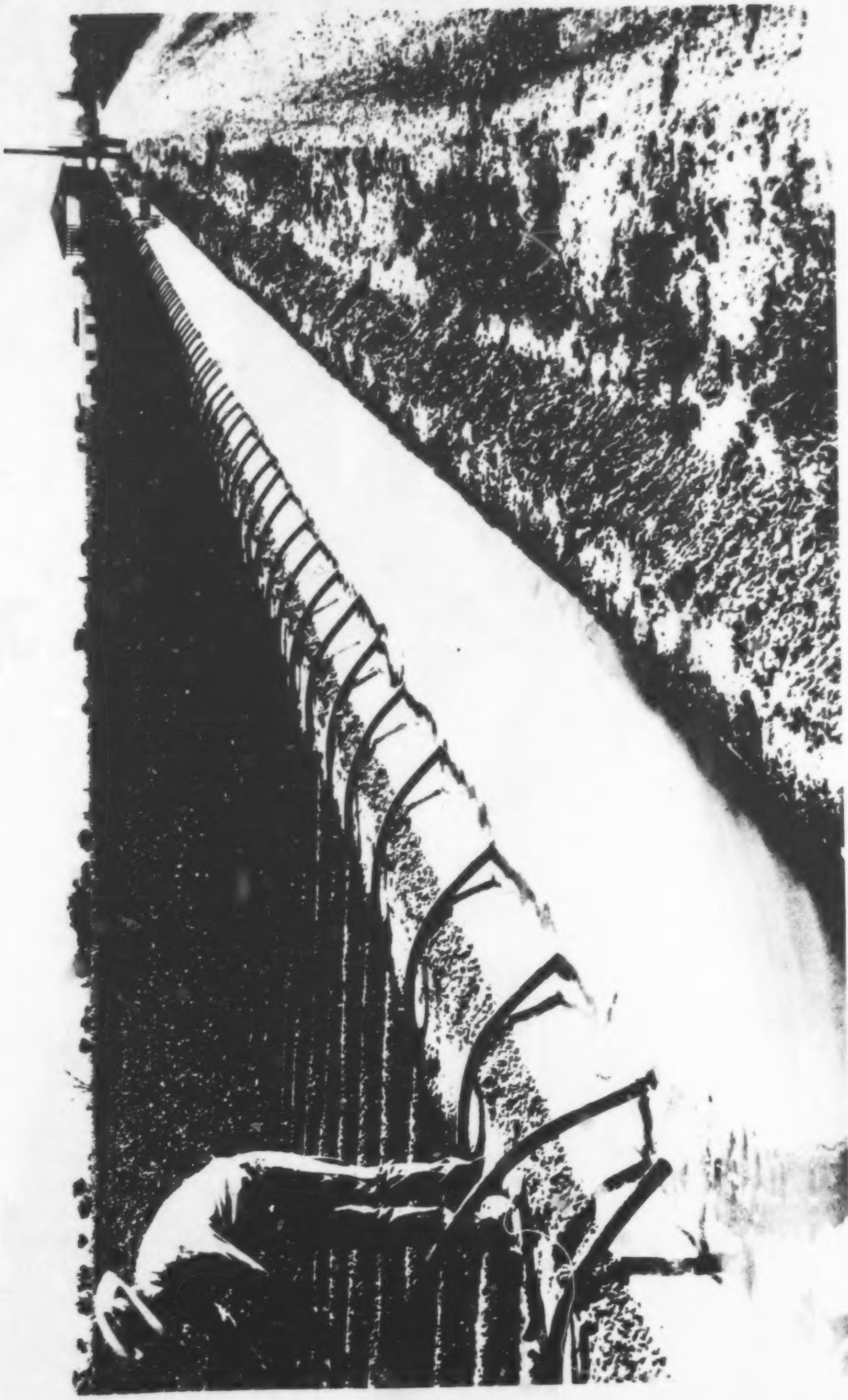

Figure 3-28 - Concrete-lined Irrigation Ditch Prevents Erosion and Prevents Seepage Losses

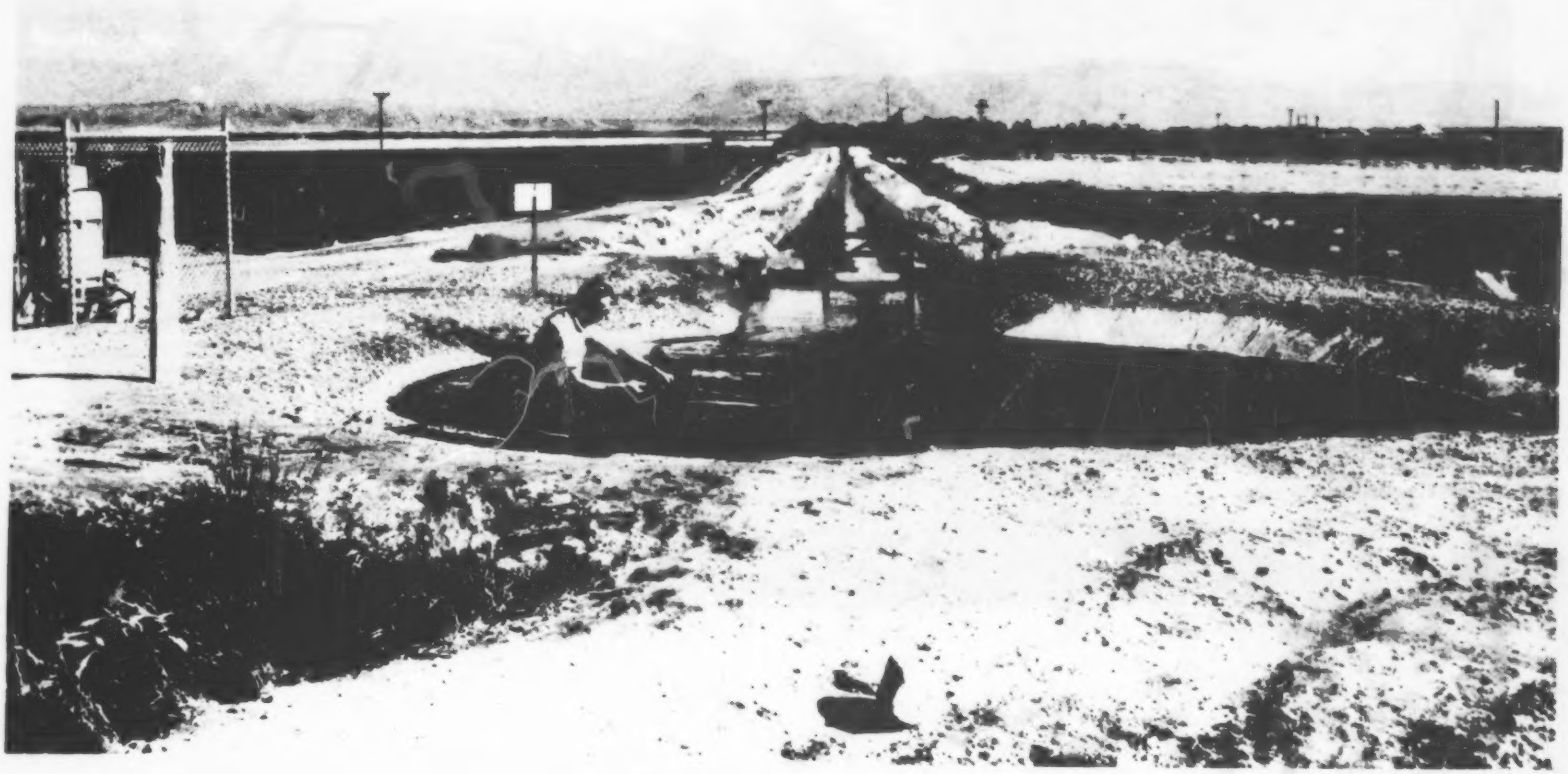

Figure 3-29 - Concrete Stilling Basin At Discharge End of Deep Well Pump Prevents Erosion of Sediments Which Can Be Transported Into Lateral System

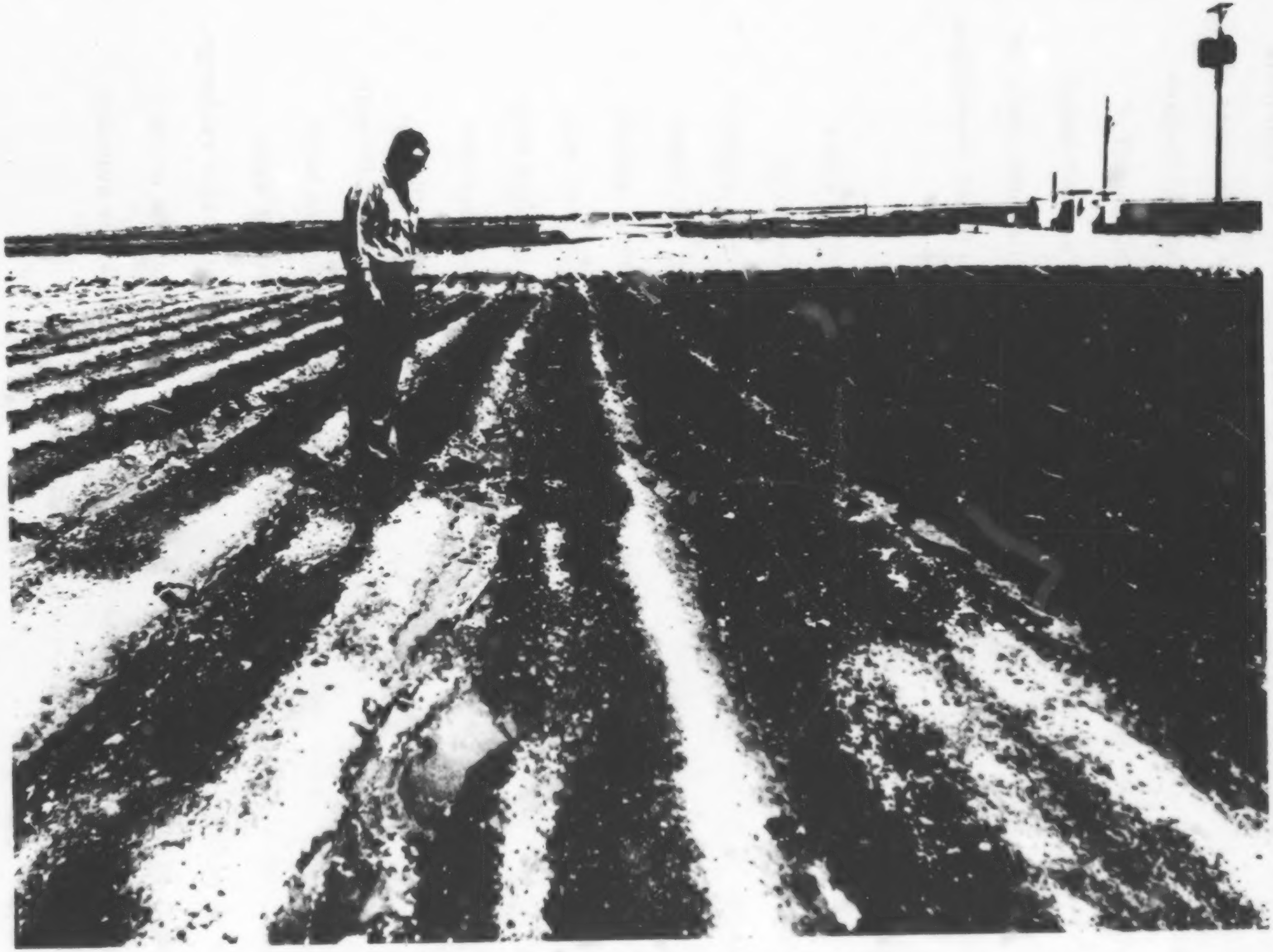

Figure 3-30 - Erosion In An Irrigated Field. Caused By Applying Too Much Water To Rows That Are Too Long (2000 feet).

As in non-irrigated crop production, effective sediment control measures will prevent the runoff of many of the fertilizers and nutrients which are adsorbed to soil particles. Using only optimum quantities of either pesticides or fertilizers and applying them at the most effective times are best management practices to minimize possible runoff of pollutants. In irrigated areas, effective management of applied water can be used to prevent movement of excess water containing nutrients, or other materials, below the root zone of crops into ground water reservoirs.

Excess Ground Water Extractions

The extraction of excess quantities of water from ground water aquifers, in excess of their long-term safe yields, can result in depletion of supplies. Ground water levels will decline and possible sea water intrusion, intrusion or interaquifer transfer of salt water from marine deposits, or subsidence of the land surface may result.

Control measures should involve the development of proper well construction procedures, effective distribution of wells, ground water recharge facilities, and possible conjuntive use of both surface and ground water supplies. Adequate well construction will prevent the movement of poor quality waters from one aquifer into another through the well bore itself. Wells distributed in patterns that prevent local concentration of pumpage, reduce the possibility of localized water table or pressure level depressions. Provision for ground water recharge, possibly in areas of excessive withdrawals and the application of conjunctive use methods will function to provide additional water supplies directly to aquifers to offset the quantities withdrawn.

Confined Animal Production

This guidance document involves control of pollution from confined animal production facilities that are not covered under the National Pollution Discharge Elimination System. Feeding operations covered by the NPDES program involve point sources and should not be considered in this guidance for nonpoint sources. The following Tables 3-2, 3-3, and 3-4 define those facilities that are controlled by the NPDES program. For more information on program elements necessary for participation in this system see the attached copy of the Federal Register, Dated March 18, 1976. (Appendix B).

Confined animal facilities vary in design from open lots where there is little cover or protection for the animals to those that are totally confined in buildings. In confined facilities, animals are completely housed to protect them from severe winter conditions and muddy ground. Feedlots with partial confinement also exist. In these latter facilities, animals are free to move about in the lot but also are provided with protective shelters or buildings (See Figure 3-31). Variations in surface configuration and characteristics of each facility can occur and lot surfaces may be unpaved, partially paved, or completely covered with an impervious material.

Best Management Practices for controlling, or preventing, the generation and runoff of nonpoint source pollution from confined animal production facilities include principally control of runoff water and the adequate storage, treatment, and disposal of waste materials (Reference No. 3-18). Runoff control involves preventing outside runoff from entering the feedlot,

Operations with 1000 or more animal units	Operations with less than 1000 but with 300 or more animal units	Operations with less than 300 animal units
Permit required for all operations with discharges of pollutants	Permit required if operation 1) Discharges pollutants through a man-made conveyance, or 2) Discharges pollutants into waters passing through or coming into direct contact with animals in the confined area.	No permit required (unless case-by-case designation as provided below)
	Operations subject to case-by-case designation requiring an individual permit only after onsite inspection and notice to the owner or operator.	Case-by-case designation only it operation 1) Discharges pollutants through a man-made conveyance, or 2) Discharges pollutants into waters passing through or coming into direct contact with the animals in the confined area; AND After on-site inspection, written notice is transmitted to the owner or operator.

Table 3-2 - Concentrated Animal Feeding Operations

where it can contact waste materials. It also includes containing runoff that has been generated within the facilities and is contaminated by manure and other wastes. Waste storage, treatment, and disposal techniques will depend upon the volume and moisture characteristics of the wastes generated, amount of acreage involved, and the type of animal production facility and wastes management system used.

Types of animals	1,000 animal unit equivalent	300 animal unit equivalent
Slaughter and feeder cattle	1,000	300
Mature dairy cattle-milker and dry	700	200
All swine over 55 pounds	2,500	750
Sheep	10,000	3,000
Turkeys-in open lots	55,000	16,500
Ducks	5,000	1,500
Laying hens and broilers:		
Facilities with continuous overflow waterers	100,000	30,000
Facilities with liquid manure handling systems	30,000	9,000

Table 3-3 - Animal Unit Equivalents

Slaughter and feeder cattle	1.0
Mature dairy cattle	1.4
Swine over 55 pounds	0.4
Sheep	0.1
Example:	
Number of animals	
Slaughter and feeder cattle	600 X 1.0=600
Mature dairy cattle	200 X 1.4=280
Swine over 55 pounds	500 X 0.4=200
Total	1080

Exemption. No animal feeding operation requires a NPDES permit if it discharges only in the event of a 25 year, 24 hour storm event.

Table 3-4 - Animal Equivalent Multiples

[Operations with 1,000 animal units are those which have the number of animals listed in Table 3-3 under the 1,000 animal unit equivalent column. Operations with 300 animal units are those which have the number of animals listed under the 300 animal unit equivalent column. Table 3-4 lists the multiples to be used when figuring the number of animal units at an operation if a combination of types of animals is involved.]

Studies have been conducted regarding recycling of feedlot wastes as livestock feed (Reference No. 3-17). Partial or continuous recycling of these wastes as feed materials could reduce the total amount of wastes required to be disposed and also the biological oxygen demand associated with its decomposition through the loss of organic matter. Animal wastes may provide such useful nutrients as fiber, nitrogen, energy and minerals in the diet of livestock.

Control of Outside Runoff

Runoff water from outside of confined animal production facilities must be prevented from entering unless it is an integral part of the designed disposal system Figure 3-31). It prevents uncontaminated runoff from contacting manure and other wastes and transporting them from the site area. It also reduces the volume of water which must be collected and disposed of or treated.

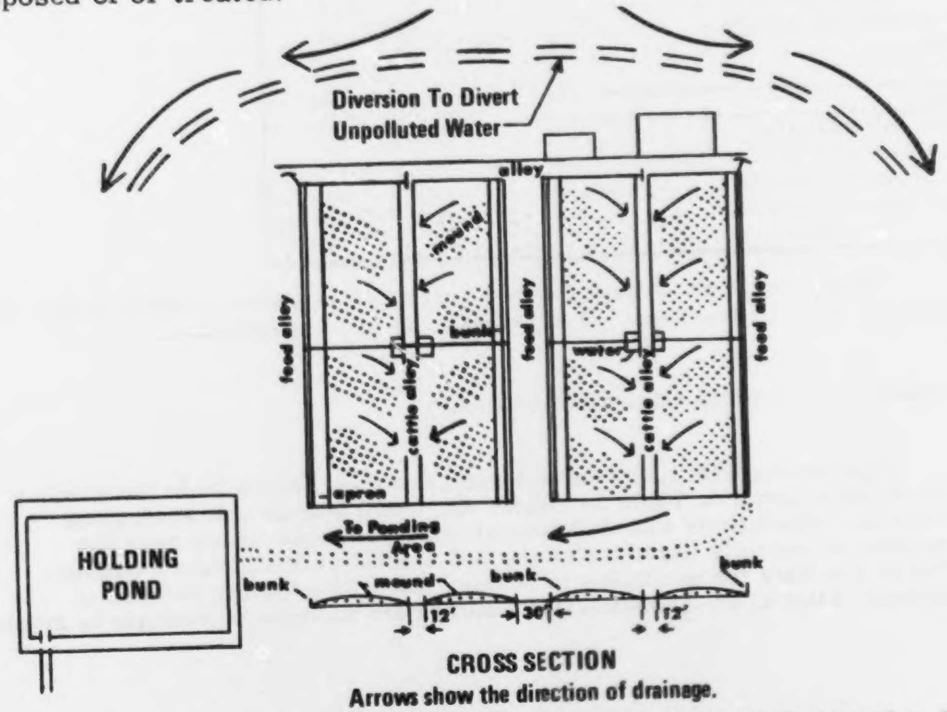
Diversion To Divert
Unpolluted Water
alley
feed alley
mound
bunk
cattle alley
water
feed alley
cattle alley
feed alley
apron
To Ponding Area
HOLDING POND
bunk
mound
bunk
bunk
12'
30'
12'
CROSS SECTION
Arrows show the direction of drainage.

Figure 3-31 - Sketch and Cross-section of Confined Animal Production Facility Showing Diversions Which Prevent Runoff From Entering The Site and Directing Contaminated Runoff Into a Holding Pond. Note Cross-section Showing Topography of Facility.

Proper location of the facilities with regard to topography, soils and geologic conditions, ground water and surface water proximity will help minimize the possibility of outside surface water entering the facility. Perimeter diversion ditches and/or berms are the principal structures to divert surface runoff from upslope areas and by-pass it into adjacent well protected areas. Ground water or springs that could discharge into the feedlot may be cut off above their source areas by drain wells, "french drains", or other measures and diverted to a protected area. Capacity for the selected design storm, with an added factor for safety, must be provided for these structures to ensure control of the runoff. Design storms must be selected in accordance with local precipitation, soils, vegetative, and other conditions.

If a stream extends into the confined animal facility, relocation should be considered, or the stream diverted away from, or around, the area. This may involve the use of diversion structures, lined channel sections, or perhaps pipelines.

Onsite Runoff Control

Runoff water that has come into contact with manures and other wastes must be prevented from leaving the animal production facility to degrade quality of water further downstream. The slope of the animal production facility must be adequate to remove runoff quickly and drainage channels, or other structural measures such as diversions, must be provided to ensure transmittal of fluids to collection or retention structures. Since some solid materials are usually carried in the runoff, some consideration within the design of the system must provide for their removal. Porous dams or some other structural measures in drainage channels can be used to decrease the velocity of runoff flow and allow settlement of solids. Removal of the settled solids can be done during dry periods with mechanized equipment. If needed, draglines, can be used during wet conditions to remove the solids. Disposal of these materials should be where they are not apt to be transported into water bodies by runoff (See Page 3-51).

Settling basins at the end of conveyance channels can efficiently remove much of the solids contained in the runoff. Since they may be relatively deep in order to provide sufficient storage space, removal of solids from them may be difficult without special types of equipment. Many different types of ponds with varied outlet elevations can be designed for the most efficient solids removal. During design, consideration should be made with regard to how the solids are to be removed from each structure in order to ensure that retention capacities are maintained (Figure 3-32). Outlet pipes or some other types of structures or pumps, must be used to dewater the basins for removal of the solids.

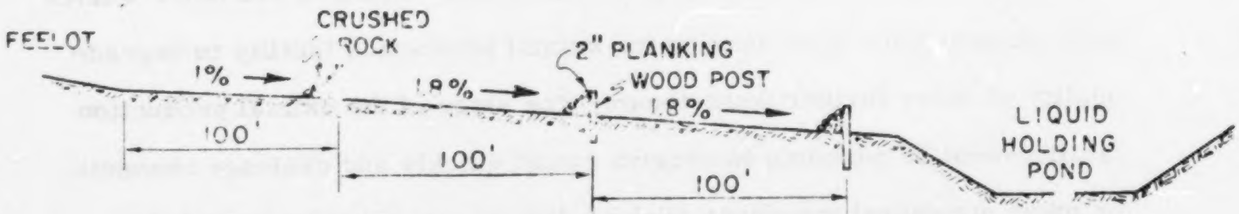

Figure 3-32 - Sketch of A Series of Porous Dams Forming Settling Basins For Removing Solids From Runoff Prior to Entering Holding Pond. Crushed Rock Will Require Periodic Cleaning or Replacement to Retain Filtering Capacity

Settling basins can be constructed in the form of terraces or multiple terraces. They provide large areas for storage over periods of time to allow for efficient solids removal.

Collection or holding ponds, are used to provide storage of fluids until disposal can be accomplished (See Figure 3-32 and 3-33). They should be designed to store the volume needed for disposal management with an additional storage capacity to accommodate runoff from the estimated design storm. Some sources estimate that the management volume should be at least 50% of the volume expected from the design storm (Reference No. 3-18).

Any fluid detention facility must be designed with subsurface conditions in mind so that infiltration of pollutants does not create a ground water problem. Particularly in areas of shallow water table conditions, ground water pollution is always a potential unless the bottoms of ponds containing pollutants are sealed with impervious "blankets" of clay or other materials.

Disposal of Wastes In Runoff Water

Disposing of wastes carried by runoff from animal production facilities on the land probably is the most economical and practical means of getting rid of potential pollutant materials. It involves waste disposal by evaporation and/or irrigation practices.

Disposal By Evaporation: Evaporation of liquid wastes may be the most economical method in areas of the U.S. where the annual evaporation exceeds precipitation by 762 millimeters (30 inches) (Reference No. 3-18). Lagoons for evaporation purposes must provide a surface area sufficient to result in evaporation of one year's waste fluid plus the quantity of rain that falls within the structure. Open areas with fairly continuous winds blowing across them will be favorable for high/evaporation rates. An additional "safety factor" should be provided to make up for additional capacity required during exceedingly wet years. Figure 3-33 presents a map of the U. S. showing contours of the moisture deficit (annual evaporation minus rainfall). The 762 millimeter contour line extends through the extremely southwestern portion of the U. S.

Design of the evaporation disposal facility should consider the monthly rainfall, evaporation, and runoff quantities to be involved in the area in order to determine the size of the facility needed for evaporation disposal. Rainfall and evaporation data can be obtained from the U. S. National Weather Service, Department of Commerce. The amount of rainfall that actually becomes runoff from an area can be estimated in several ways. Probably the most applicable provides information on estimating runoff through the use of "Watershed Curve Numbers". It is presented in the Soil Conservation Service "National Engineering Handbook, Section 4, Hydrology" and "Engineering Field Manual" (Reference No. 3-2). The curve numbers are "soil-cover" complex numbers which indicate their relative value as direct runoff produces. The higher the number, the greater the runoff to be expected from a storm.

Large areas of land are usually required for evaporation processes and the design of ponds should provide for the largest surface area possible. Reshaping of the land or grade separation structures may be required to do this.

Disposal by Irrigation: Disposing of feedlot wastes by irrigation is probably the most practical disposal method. It can be used to provide nutrients needed for crop production or just used to get rid

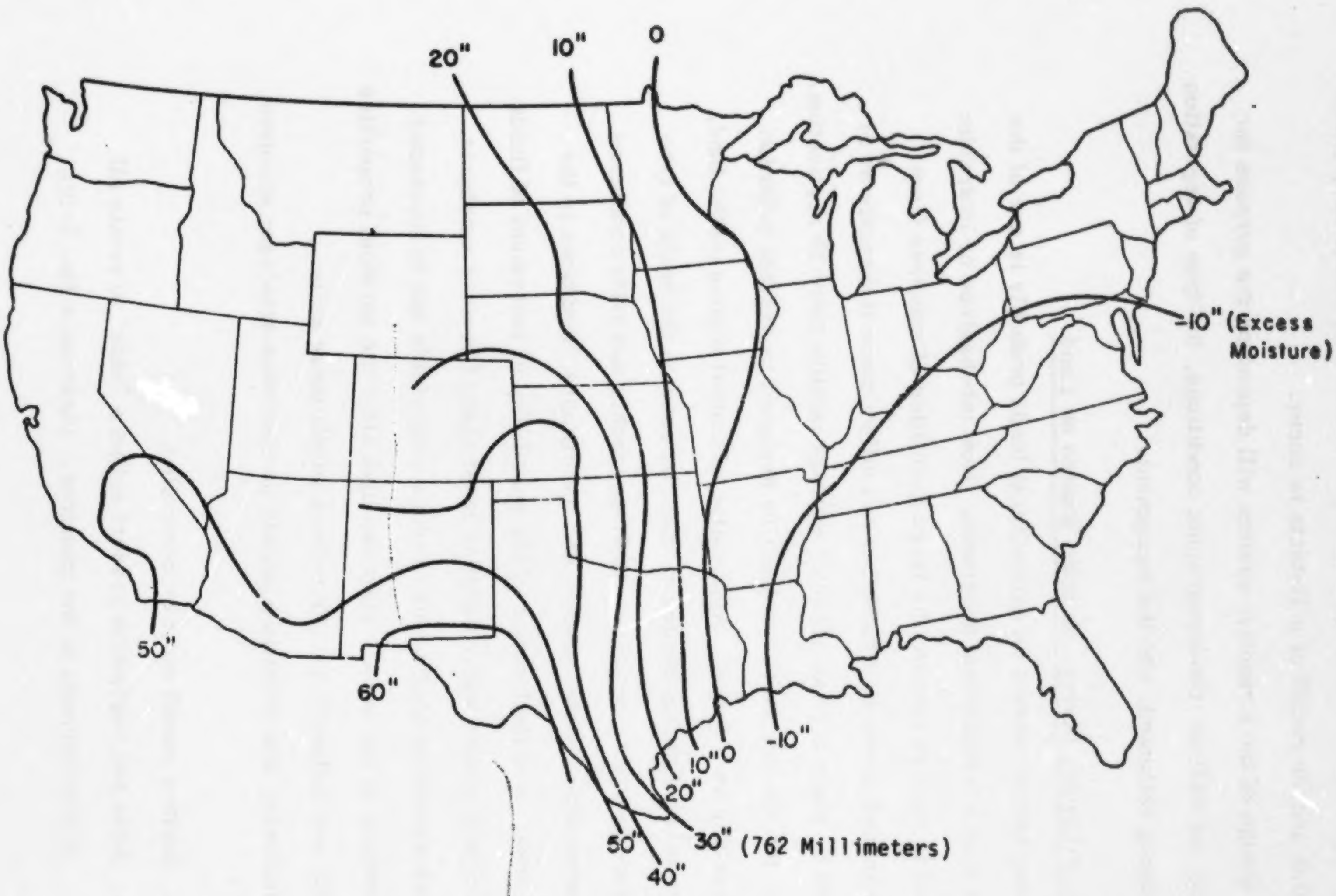
20"
10"
0
-10" (Excess Moisture)
-10"
10"
0
20"
30" (762 Millimeters)
40"
50"
60"
50"

Figure 3-33 - LINES OF MOISTURE DEFICIT FOR THE UNITED STATES

of waste materials. Excess application of wastes may cause crop yields to diminish and/or runoff of pollutants to occur.

The design of the irrigation system will depend on the purpose for irrigating, as well as, the topographic conditions, the type of vegetation or crop being irrigated, and the equipment.

Disposal of Liquid, Slurry, or Solid Wastes on Land

Placing animal wastes on agricultural lands probably is one of the oldest of man's fertilization programs. Now mechanized or hydraulic equipment is used to remove the large quantities of manures from confined animal production facilities and either place it directly on or in the soil or place it in an adequate storage facility prior to application. If stored, the storage facilities must be designed to prevent pollution from occurring as a result. Application of animal wastes on the land, similar to other disposal methods, must be done on the basis of type of crop expected to be produced, the topographic and soils conditions, the characteristics of the wastes, and the climatic conditions in the disposal area. A consideration of the possibility of movement of fluids into underlying ground water supplies must always receive emphasis.

Excess quantities applied may reduce crop yields due to increased in salt contents in the soils. They can also alter the physical properties of the soils and influence the microflora within these soils.

The following site conditions should be met when disposing manures on land:

1. Surface runoff must be controlled.
2. Soils and vegetation present act as a "sink" to retain all of the nutrients in the manures. (Reference No. 3-19).

Wastes should be spread as uniformly as possible and incorporated into the soils. Incorporation into soil layers greatly reduces the chance of them being transported from the site by runoff waters. Scheduling of manure application should be done so that the chances of the materials remaining in place are optimal. This involves times when vegetation or crop residues are at their maximum and runoff at a minimum. Any practices or activities that can minimize or prevent the contact between runoff water and applied manures, which promote the infiltration of rainfall, or reduce the quantity of runoff also act to prevent or reduce the pollution potential of animal wastes applied to the land. They can involve application just prior to plowing, or on plowed fields; before the snow season begins so the snow cover provides some protection from runoff; or early enough for growing crops to utilize many of the nutrients available (Figures 3-34 and 3-35).

Application rates depend on the ability of the soils and crops, or other vegetation, to utilize or otherwise fix the nutrients in place. Since the animal manures must remain where applied for these processes to take place, the soil characteristics such as permeability, depth, and chemical quality must be considered. Additional factors of importance are the slope of the land, type of vegetative cover, and the climate and length of growing season (Reference No. 3-19).

Pastured and Grazing Animal Production

Pastured and grazing animals are essentially living under unconfined conditions. If properly done, this is probably the most environmentally sound method of containing animals for man's use with regard to pollution prevention. Concentrations of the animals, and the most severe nonpoint

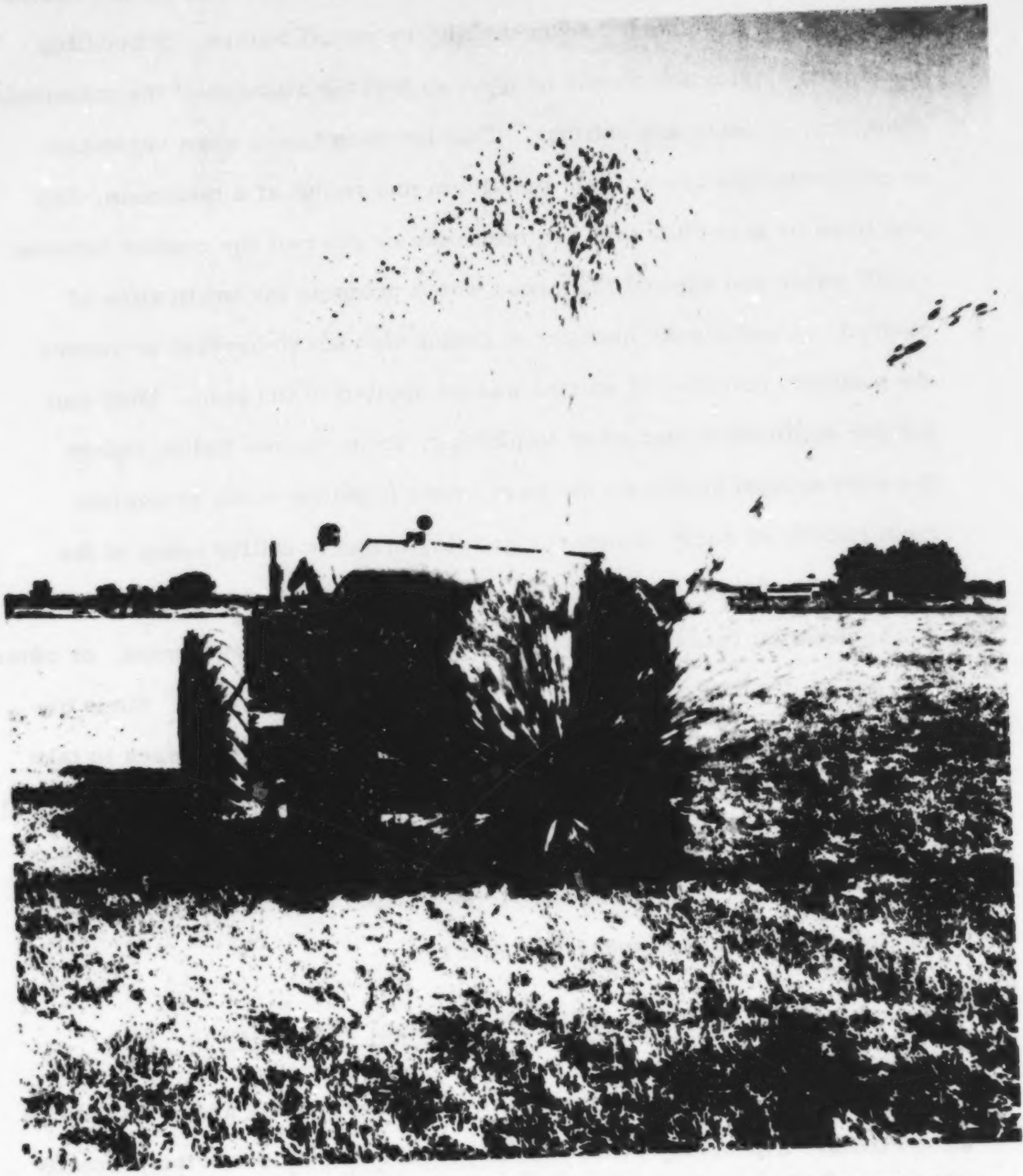

Figure 3-34 - Liquid, or Slurry, Wastes From Confined Animal Production Facilities Being Applied to Alfalfa After First Cutting

Figure 3-35 - Applying Solid Animal Wastes (Manures) To Freshly-Plowed Ground

source pollution problems, occur in the vicinity of watering, feeding, milking, and probably "loafing" areas. Overgrazing, or the use of the land by too many animals for too long a period of time, creates a most severe problem, particularly with regard to erosion and sediment losses.

Control through Best Management Practices, as with other agricultural activities, involves first developing and then implementing one or more of many animal management systems to minimize or prevent the generation of a pollution problem. This will involve an evaluation of the forage capacity of the land, grazing habits and schedules of the animals, physical and chemical characteristics of the soils, the slope and other topographical conditions of the area, and the climatic conditions. Uniform distribution of livestock grazing will help prevent localized problems while other areas are in good condition. Use of proper grazing practices will prevent detrimental plant composition changes that could ultimately result in conditions favorable for extensive erosion and sediment losses.

Animals graze their pastures and rangelands selectively by both plant species and areas (Reference No. 3-20). The more palatable plants and easily accessible areas will be used more consistently than other sources. Continuous grazing by the same type of animal, and in the same season at normal stocking rate, tends to result in the most palatable and accessible vegetation being depleted. The remaining plants will successively be eradicated to ruin the pasture and deplete its protective vegetative cover. Proper management can prevent this by periodically resting the pasture or rangeland or possibly alternating, different types of grazing animals on the land. The purpose of resting western rangelands is to:

1. Permit plants the opportunity to renew their vigor.
2. Allow seeds to ripen and seedlings to be established.
3. Allow plant residue to accumulate on the ground surface.

The amount of rest required for a range or pasture is determined by the condition of the plant species that have been severely overused during the critical green period. In semiarid western grazing, a period of 1 to 2 years is adequate; however, other grazing - resting treatments can be used. A five-cycle treatment formula developed for the western area is illustrated in Figure 3-36 below.

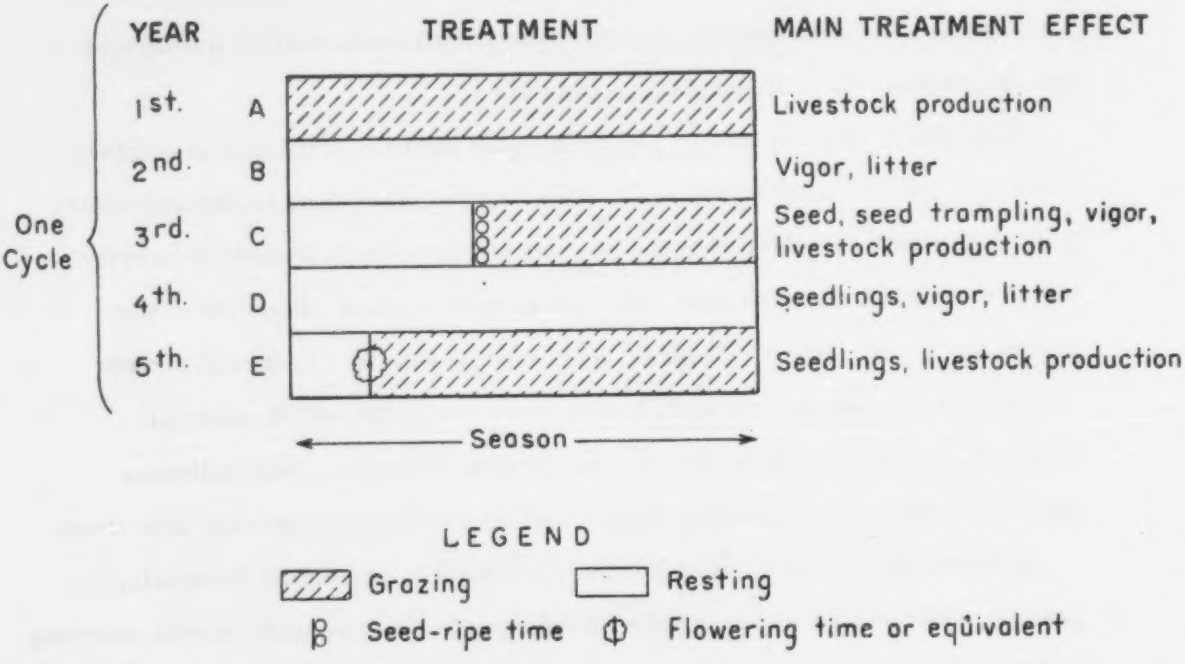
YEAR
TREATMENT
MAIN TREATMENT EFFECT
One Cycle
1st. A
Livestock production
2nd. B
Vigor, litter
3rd. C
Seed, seed trampling, vigor, livestock production
4th. D
Seedlings, vigor, litter
5th. E
Seedlings, livestock production
Season
LEGEND
Grazing
Resting
Seed-ripe time
Flowering time or equivalent

Figure 3-36 - A 5-Treatment Grazing Formula (From Reference No. 3-20).

The end results to be achieved by such a cycle of treatments include increased plant vigor, more plants produced, and increased litter on the ground to protect the soil. Grazing after the seed ripe time of Cycle 3 is important for getting seedlings established as the seeds are trampled into the soil. If trampled into the soil at only a shallow depth, they have an increased chance for germination and the establishment of seedlings. Seeds should be trampled as soon as possible after falling to minimize losses to birds, animals, and insects. These treatments keep the pasture or range in adequate condition for grazing.

There are many alternative systems of sound grazing practices which can be used to minimize or prevent pollution. It will necessarily be based on a knowledge of the local conditions. By ensuring a vigorous and extensive vegetative ground cover and protected and productive soil, the potential for pollution by nonpoint source pollutants will be minimized and the production of livestock maximized.

Each year, approximately 30% of the root system of rangeland grasses must be replaced (Reference 3-21). This is necessary for healthy reproduction. A test has indicated that the amount of leaf volume removed directly affect the growth of new roots. All root growth stopped when 80% of the leaves were cut. When 90% of the leaves were removed, all root growth ceased and did not resume until leaves grew back. Repeated removal of leaves resulted in more severe root growth stoppage. This indicates again that pasture and grazing lands must be rested from grazing activities.

A knowledge of the grazing habits of animals is important in developing grazing management plans. Cattle usually graze from sunrise to mid-morning and from late afternoon to sunset. Grazing also may occur during short periods at night. For example, cattle graze for 6 to 10 hours and travel from 3 to 8 kilometers (about 2 to 5 miles) during the day. During the remainder of the time travel is done for the purpose of using sources of water, salts, and other minerals and to loaf in shaded areas while ruminating.

Since cattle, and other animals, use some portions of pastures more heavily than others, due to grazing preferences, vegetation will be depleted principally in these areas unless suitable management is practiced. If the depletion is too severe, erosion and sediment losses may become extensive. The grazing distribution problem may be resolved and sediment pollution prevented by locating water, salt and mineral, and other sources in accordance with range conditions. Since cattle travel to their water supplies and salt and mineral sources periodically each day, they tend to overgraze their routes to them. Providing additional water sources and locating salt and mineral facilities in undergrazed areas away from water supplies will give cattle the incentive to graze more uniformly over an area. (See Figures 3-37 and 3-38).

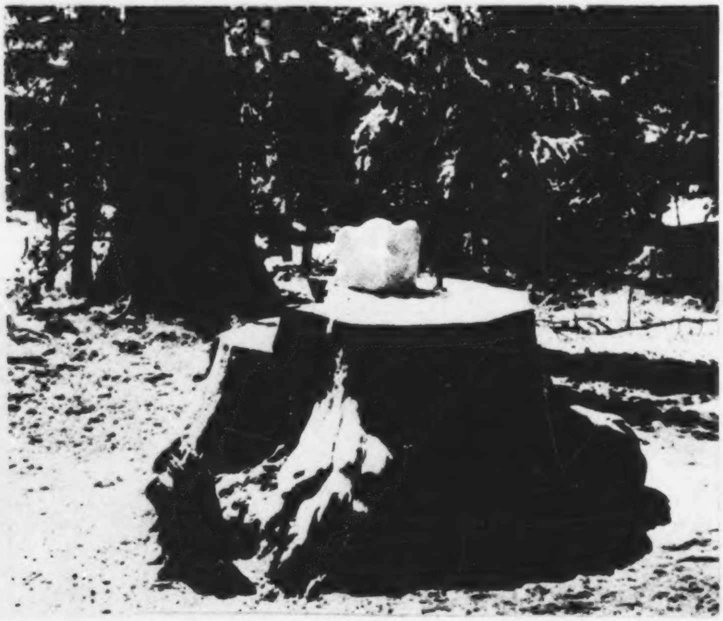

Figure 3-37 - Temporary Salt Lick Can Be Easily Relocated. (Reference No. 3-22

Figure 3-38 - Small Water Pond Helps Relieve Grazing Pressure In Other Areas Where Use May Be Excessive. (Reference No. 22)

A simple technique for determining where and how much grazing is going on is to fence in a small square of vegetation and leave it for the rest of the season (Figure 3-39). It will quickly be apparent how much of the vegetation has been removed.

Figure 3-39 - Fenced Plot Indicating The Amount of Grazing Which Has Occurred Outside Its Boundaries. (Reference No. 21).

Streams and other water bodies in pastures or grazing land can be to a great extent protected from pollution by nonpoint sources activities if heavily grassed buffer strips are maintained adjacent to them. These strips serve to decrease the velocity of sheet flow and to filter out sediment and other pollutants being transported in runoff. If fencing or some other techniques are used to keep animals out of these buffers to prevent overgrazing, they will maintain their effectiveness and the pollution potential will be minimized. In critical areas, measures to prevent the physical contact between the animals and the water may be necessary.

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CHAPTER 4

METHODOLOGY FOR ASSESSMENT OF POTENTIAL AGRICULTURAL NONPOINT SOURCE POLLUTION PROBLEMS

The worldwide demand for agricultural products has caused an intensification of crop and animal production in the U. S. The trend is to employ modern technology to increase production on existing farm lands and to place additional, and often marginal, lands into production. This generally increases the quantities of fertilizers, pesticides, irrigation waters, and other materials used. As a result, the potential for pollution increases.

To some extent, nonpoint source pollution will result when any lands are subjected to man's agricultural activities. If soil surfaces are disturbed; surface runoff increased or concentrated; vegetation removed; pesticides, nutrients, or other materials applied to the ground in greater quantities than can be consumed by crops or organisms; or salts are concentrated and removed from irrigated lands by applied water, pollution can result. Only the magnitude and extent of this pollution needs to be estimated.

This chapter provides information which can be used to predict and approximate the magnitude of nonpoint source pollution which could result from new lands being subjected to agricultural production activities or existing farm lands where production is intensified or changed. The methods discussed provide approximations only and should be used with care by personnel that are competent in their use. Further and more detailed information on methods will be presented in the Handbooks discussed in Appendix A.

The assessment studies may indicate that certain areas are so sensitive to changes caused by man's activities that they should be left in their natural grassland or woodland state and not placed into production. This may be due to the possible magnitude of the potential pollution problems to be created or to the costs required to prevent, or mitigate, environmental damages. Highly-erodible soils on steep slopes, proximity to high-quality surface or ground waters, occurrence of excess-natural salts or other materials, and similar factors may initiate problems that are extremely difficult to prevent or correct.

To assess the potential for proposed agricultural activities to generate nonpoint source pollutants in an area and release them into waterways, all available pertinent information must be obtained regarding the type of activities to be conducted and the local climatic, soils, topographic, and other conditions. The information on activities needed should include the types of products to be produced (crops or animals) and their arrangement, density, or pattern; kinds of tillage practices or other soil-disturbing activities to be conducted; what pesticides, fertilizers, crop residueus, or other additives are to be applied or disposed of; if irrigation water is to be applied and what type of system is to be used, kinds of nonpoint source pollution control measures proposed, and other data. Data on area conditions necessary for assessment of the nonpoint source pollution potential should include the quantity, frequency, and intensity of precipitation expected; prevailing wind directions and velocities; composition, permeability, thickness, and other physical characteristics of soils; proximity of the area to surface water bodies, depth to ground water, and the quality of each water source that could be affected by the activities; possible occurrence of saline materials in or below soil horizons; and other factors.

Chapter 2 provides sources for obtaining some of this information and emphasizes that the generation and runoff of pollution from agricultural areas are strongly dependent on climatic and other conditions that often are highly variable. Many times, information needed to assess potential pollution from nonpoint sources in areas that have never been subjected to agricultural activities is lacking, particularly from readily available agricultural sources. In this case, information sources may exist as research reports or project reports done for other than agricultural purposes. If not, it will have to be obtained by sampling or testing or even estimated. Many times data can be obtained from a similar area and interpolated for use.

Pollutants To Be Considered

Possible nonpoint source pollutants to consider for an area to be subjected to agricultural activities for the first time or where activities are being changed or intensified are discussed in some detail in Chapter 1 "Existing Problem Identification and Assessment". As a result, only a summary will be provided here.

Nonpoint source pollutants generated by agricultural activities include sediments nutrients, pesticides, salts, organic materials, and pathogens. Many of the activities generate the same type of pollutants; however, the magnitude and extent of the pollution resulting differs. They are uniquely characteristic of the type of activity involved and so may require different assessment techniques for determining the potential for pollution. Sediments are generally considered the major pollutants from agriculture. They are generated by any activity that disturbs the ground surface and leaves it exposed to rainfall, wind, and runoff. Pollution from pesticides and nutrients generally result from applied materials placed on croplands; however, nutrients can be major problems as a result of wastes from feedlots and the animal production facilities. Salts generally become nonpoint source pollutants as a result of irrigation of croplands. Salts fed to animals in confined feeding facilities, however, can also become potential pollutants. Organics and pathogens result from animal production facilities. Probably confined facilities are the greatest potential sources but pasture and rangelands can be water quality problems if the animals can come into contact with water sources.

Probably, the only useful prediction methods that are available to assess potential nonpoint source pollution problems involve sediment losses. Methods to assess the potential for pollution from other materials consist of comparing activities conducted in other similar areas and in past times and the pollution resulting from these activities with pollution to be expected from new areas of production. They will include evaluation and comparison of management activities; application of pesticides, nutrients and other materials; soils, geologic, topographic, ground and surface water, and climatic conditions; and control measures applied. If nonpoint pollution has occurred in the past from certain agricultural activities, it is reasonable to assume that it will occur in new areas if the same conditions exist and the activities are similar. Only the application of Best Management Practices will reduce or prevent the generation and runoff of the pollutants.

Assessing Potential Sediment Problems

Any agricultural activities which remove the vegetative cover from the ground surface or disturb the soils and leave them exposed to the energy of rainfall, wind, or runoff water create the potential for nonpoint source pollution. Erosion will occur and transporting agents will carry sediment, perhaps with other pollutants, downstream toward water bodies. If no pollution control measures are provided to prevent or control this type of pollution, it will not be necessary to determine if soil losses will occur, but only to determine their magnitude and extent.

If new lands to be placed into production or agricultural practices are to be changed on lands previously under production, the potential for nonpoint source pollution exists. One way of estimating this potential is to compare soils, topographic cover, and climatic factors in the new area with adjacent areas which are under production. If conditions are similar, the same potential for sediment losses will exist for the new lands as for the ones under production. Losses from sheet and rill erosion processes on the new lands can be estimated by using the Universal Soil Loss Equation A=RKLSCP. This equation, and the factors in it, are briefly discussed in Chapter 2, Pages 2-18 and 2-19.

Runoff Determinations

Since erosion by water and the resulting soil losses from an agricultural area is minor until runoff actually occurs, an estimation of the amount of runoff to be expected in an area to be placed into production should be conducted. This involves an evaluation of the combined effect of soils, vegetative cover, topography, and other factors on the amount of precipitation that actually becomes runoff in an area. Probably the most applicable method for estimating runoff in this manner is presented in the SCS "National Engineering Handbook, Section 4, Hydrology" (Reference No. 4-1).

A graph for the rapid determination of the quantity of runoff from an area is presented in Figure 4-1. It is based upon a rainfall-runoff relation formula and "soil-cover" complex curve numbers (CN's). The curve numbers indicate the potential for runoff to occur when the ground is not frozen. They are dependent upon the physical characteristics of the soils in the basin and land use and treatment effects. Land use includes the types of vegetative cover, litter or mulch, water surfaces, or impervious surfaces existing in the area. Land treatment involves any practice which may have been conducted or applied to revise the flow of water.

The curve numbers indicate their relative value as direct runoff producers. The higher the number, the greater amount of direct runoff to be expected from a storm. Table 4-1 illustrates the types of curve numbers obtained. Most areas, prior to being placed into agricultural production, probably will approximate meadow and woods CN's. Soil groups are characterized according to ability to absorb and transmit water, with Group A being permeable and having a high infiltration rate. Group D is the most impermeable and so has the highest runoff potential.

Sediment Losses

Sediment losses from an area can result from sheet and rill, gully, or streambank erosion processes. Information for assessing these losses can be found in Reference Nos. 4-2 through 4-7. A brief discussion on sheet and rill erosion losses, along with an explanation of the Universal Soil Loss Equation is presented on Pages 2-15 and 2-16 of Chapter 2. In some areas, detailed or up-to-date soils and other information may be lacking because no agricultural activities have been in operation. Numerical

HYDROLOGY: SOLUTION OF RUNOFF EQUATION $Q = \frac{(P-0.2S)^2}{P+0.8S}$

P = 0 to 12 inches
Q = 0 to 8 inches

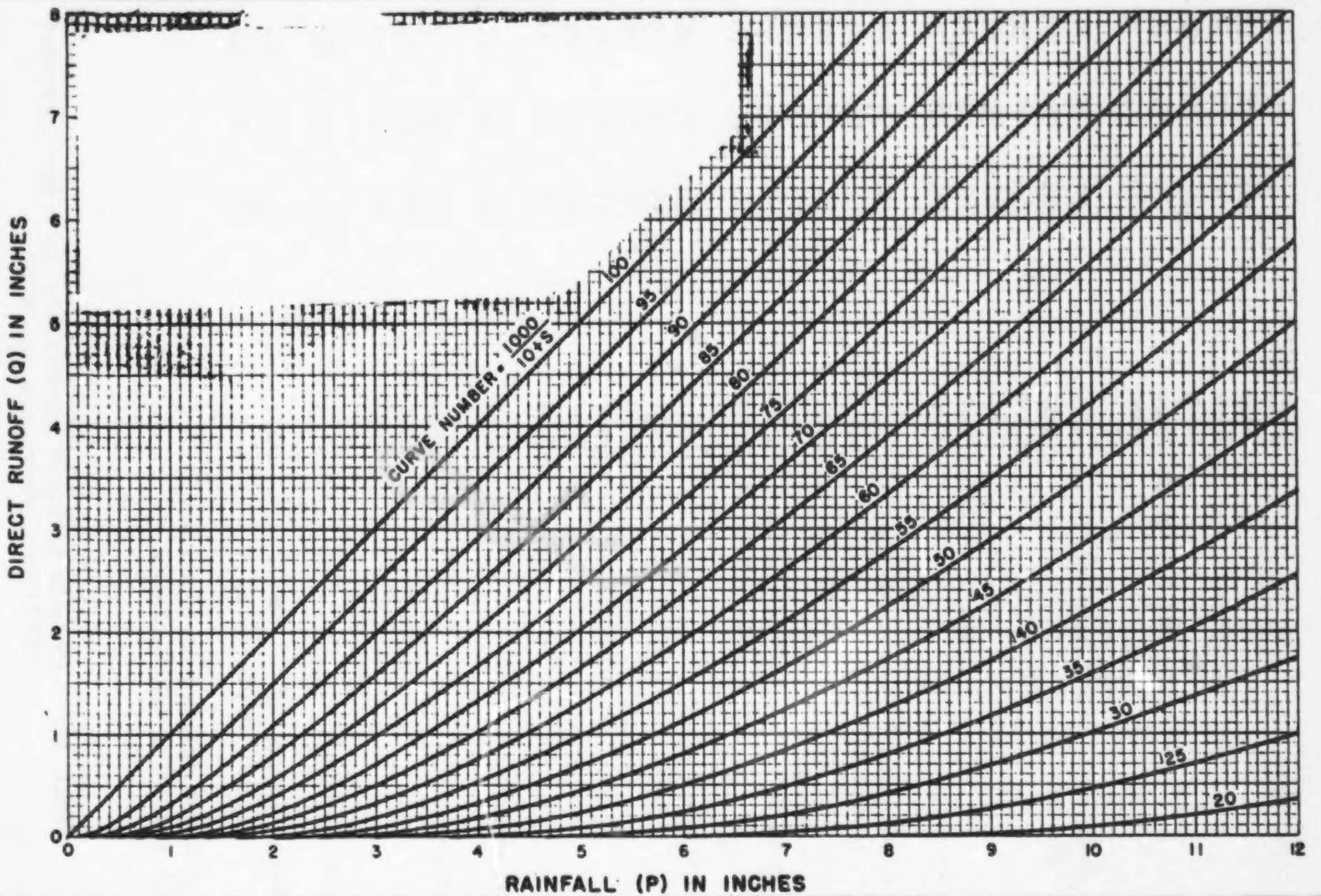

FIGURE 4-1 - Estimating Direct Runoff Amounts From Storm Rainfall (From Reference No. 4-1).

	Cover		Hydrologic soil group			
Land use	Treatment or practice	Hydrologic condition	A	B	C	D
Fallow	Straight row	----	77	86	91	94
Row crops	"	Poor	72	81	88	91
	"	Good	67	78	85	89
	Contoured	Poor	70	79	84	88
	"	Good	65	75	82	86
	"and terraced	Poor	66	74	80	82
	" " "	Good	62	71	78	81
Small grain	Straight row	Poor	65	76	84	88
		Good	63	75	83	87
	Contoured	Poor	63	74	82	85
		Good	61	73	81	84
	"and terraced	Poor	61	72	79	82
		Good	59	70	78	81
Close-seeded legumes 1/ or rotation meadow	Straight row	Poor	66	77	85	89
	" "	Good	58	72	81	85
	Contoured	Poor	64	75	83	85
	"	Good	55	69	78	83
	"and terraced	Poor	63	73	80	83
	"and terraced	Good	51	67	76	80
Pasture or range		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
	Contoured	Poor	47	67	81	88
	"	Fair	25	59	75	83
	"	Good	6	35	70	79
Meadow		Good	30	58	71	78
Woods		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	25	55	70	77
Farmsteads		----	59	74	82	86
Roads (dirt) 2/		----	72	82	87	89
(hard surface) 2/		---	74	84	90	92

1/ Close-drilled or broadcast.
2/ Including right-of-way.

TABLE 4-1 - Example of Curve Numbers For Soil and Treatment Conditions (Reference No. 4-1).

values for factors in the equation may not be available for these lands and must be obtained by sampling and testing or estimated. They could include the soil erodibility factor (K), the length and slope factors (L and S), and possibly the ground cover factor (C). The rainfall and runoff erosivity index (R) will probably be similar to that in adjacent lands that are under production. The supporting practice factor (P) will be 1 as no support factor will have been applied to the lands where no production has been carried out or that has not been in production for a period of time.

Through the use of the USLE, with the estimated numerical values for each factor, an approximate evaluation of potential soil losses can be obtained. If more precise data on the values of the factors become available from prior studies or other sources, the soil loss estimates will become more accurate.

Gully erosion is a more advanced type of erosion than the sheet and rill process and results from conditions which concentrate the flow of runoff. The characteristics of soils, geologic, topographic, and volume of runoff control the rate of a gully development and advance. Probably the only way to predict potential sediment problems from gully erosion is to compare the area that is planned to be placed into production, or where agricultural practices are to be changed, with a similar area where production is presently taking place. If the area in production is affected by gullying and has similar soils, slopes, ground cover, and other conditions, gully erosion can also be expected in the planned new area when production takes place.

Measurement of the volume of sedimentary materials removed from the gullys with a time period will indicate the quantity of sediments to be lost from the area. If different soils, geologic, topographic, or other conditions are known to exist in the new area, an estimate may be made as to how they could affect the soil losses from gully erosion.

Erosion from wind forces may be predicted through the use of data, maps, and guidance presented in "Wind Erosion Forces In The United States and Their Use In Predicting Soil Loss". The information presented includes the capacity of the wind to cause erosion of unprotected soils, the preponderance of wind erosion forces in the prevailing direction of the winds, and the prevailing wind direction throughout the United States.

Generally, wind erosion forces are highest in the spring of the year and lowest during the summer. Some areas, however, might have their highest erosion forces during the summer. Table 4-2 provides information on wind forces and direction in several areas of Arizona and California.

As discussed in Chapter 2, determination of wind forces presents only a part of the picture regarding wind erosion. The physical characteristics of the ground cover which the wind travels must also be considered in evaluating the potential for erosion. The surface roughness, moisture content and cohesiveness of the soils; quantity, type and arrangement of the vegetation or crops grown; and the "fetch", or distance across the field that the wind can move without an obstruction changing its velocity.

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Kingman, Ariz. (Mar. 1943 – June 1945)												
Magnitude	150	244	337	256	280	329	225	181	162	98	83	66
Direction	45	67	67	45	45	45	45	45	45	45	45	90
Preponderance	2.9	1.7	2.6	2.8	2.7	3.6	2.4	2.9	1.9	1.5	2.0	1.6
Phoenix, Ariz. (May 1950 – Apr. 1955)												
Magnitude	45	101	74	93	89	62	131	97	76	34	29	38
Direction	180	157	158	180	113	135	90	135	112	90	90	113
Preponderance	1.5	1.4	1.6	1.7	1.4	1.5	1.5	1.7	1.7	1.6	1.0	1.4
Prescott, Ariz. (Jan. 1953 – Jan. 1963)												
Magnitude	69	128	194	236	242	204	103	75	88	85	76	57
Direction	68	68	45	67	67	45	45	67	67	68	68	68
Preponderance	1.7	1.4	1.7	2.0	2.7	2.3	1.9	1.6	2.0	2.1	2.2	1.5
Tucson, Ariz. (Sept. 1952 – Jan. 1963)												
Magnitude	93	82	101	121	132	91	96	63	70	107	106	87
Direction	157	158	158	180	22	158	157	157	157	157	157	157
Preponderance	2.6	1.7	1.6	1.4	1.7	1.2	1.5	1.6	2.1	2.3	3.4	2.6
Yuma, Ariz. (Sept. 1952 – Jan. 1963)												
Magnitude	62	90	89	111	108	107	139	114	43	45	62	59
Direction	90	90	113	157	135	113	113	113	112	113	90	90
Preponderance	2.6	2.1	1.5	1.5	1.7	2.2	3.0	2.5	1.9	1.4	2.4	2.7
Arcata, Calif. (Dec. 1949 – Nov. 1958)												
Magnitude	159	154	183	172	192	140	80	54	53	81	93	126
Direction	135	135	135	135	135	135	135	135	135	114	135	135
Preponderance	2.3	2.8	3.3	3.9	4.4	6.6	6.9	5.0	3.6	2.1	3.1	2.5
Bishop, Calif. (Jan. 1948 – Jan. 1957)												
Magnitude	170	234	409	299	305	256	170	176	175	242	222	161
Direction	90	90	90	90	90	90	112	90	90	90	90	90
Preponderance	4.1	4.0	3.2	2.6	2.0	2.4	2.1	2.3	2.5	3.6	5.7	3.9
Blythe, Calif. (Aug. 1942 – May 1944)												
Magnitude	110	108	172	132	226	216	136	166	59	103	127	90
Direction	90	90	90	45	90	45	90	90	90	67	90	113
Preponderance	2.3	2.4	2.2	2.3	1.4	2.1	1.9	3.9	1.8	1.9	4.2	1.9

Direction given in degrees measured counterclockwise with East 0°
North 90°, West 180°, and South 270°

TABLE 4-2 - Relative Magnitude, Prevailing Wind Erosion Direction, and Preponderence of Wind Erosion Forces In Selected Areas. (From Reference No. 4-7).

CITED REFERENCES

4-1. U.S. Department of Agriculture, Soil Conservation Service "National Engineering Handboook, Section, Hydrology". 1972

4-2. U.S. Environmental Protection Agency and Department of Agriculture "Control of Water Pollution From Cropland - Vol. I, A manual for guideline development," EPA-600/2-75-026(a), November, 1976.

4-3. - - - - - - "Control of Water Pollution From Cropland - Volume II - An Overview," EPA-600/2-75-026(b), June 1976.

4-4. U.S. Environmental Protection Agency, "Methods For Identifying and Evaluating The Nature and Extent of Nonpoint Sources of Pollutants," EPA-430/9-73-014, October 1973.

4-5. U.S. Department of Agriculture, Agricultural Research Service "Predicting Rainfall - Erosion Losses From Cropland East of The Rocky Mountains," Agriculture Handbook No. 282, May, 1965.

4-6. - - - - -, Soil Conservation Service "Procedure for Determining Rates of Land Damage, Land Depreciation and Volume of Sediment Produced By Gully Erosion," Technical Release No. 32. July, 1966.

4-7. - - - - -, Agricultural Research Service, in cooperation with the Kansas Agricultural Experiment Station, "Wind Erosion Forces In The United States and Their Use in Predicting Soil Loss," Agricultural Handbook No. 346. April, 1968.

APPENDIX A

ABSTRACTS OF BMP HANDBOOKS

The documents described in this Appendix represent the most current efforts by EPA to establish the State-of-the-Art of various agricultural activities and to discuss management practices pertinent to water quality management planning. A few of these handbooks have been printed and are available from the sources indicated. The others will be available as listed. To obtain single copies, write to the address indicated on the last page of the Appendix.

ABSTRACTS

(1) "Control of Water Pollution from Cropland", Volume I, A manual for guideline development, November, 1975. EPA-600/2-75-026a.

The purpose of the manual is to provide information to individuals or agencies charged with developing plans for the control of reduction of pollution from nonpoint agricultural sources. Information on the sources, causes, and potentials of sediment, nutrient, and pesticide losses from ccopland is dealt with in depth, as is information on selecting cropping systems, tillage practices, and other measures that may be necessary to control pollutants. The information presented should be useful in selecting the control measures that are appropriate for the special conditions imposed by the climate, soils, topography, and farming practices of a particular land area. The manual also presents procedures for estimating the cost of various control practices at the farm level. The regional and national economic impacts of certain nonpoint pollution control methods are also discussed. Handbook Source 1, 2, 3, 4.

(2) "Control of Water Pollution from Cropland", Volume II, An Overview, February, 1977. EPA-600/2-75-026b.

The ultimate decision as to whether agriculture is contributing to pollution of particular water bodies to such an extent that active control measures are required rests with State or local authorities. To assist these officials in reaching this decision and in choosing appropriate controls, the Federal Water Pollution Control Act Amendments of 1972, Public Law No. 92-500, specify that the Administrator of the Environmental Protection Agency shall, in cooperation with other agencies, provide guidelines for identifying and evaluating the nature and extent of nonpoint sources of Pollutants. This two-volume document on control of potential water pollutants from cropland was written by scientists of the U. S. Department of Agriculture in response to this provision of the Act and at the request of the Environmental Protection Agency. Volume I is a User's Manual for guideline development. Here in Volume II we will review some of the basic principles on which control of specific pollutants is founded, provide supplementary information, and present some of the documentation used in Volume I. Handbook Source 1, 2, 3, 4.

(3) "A Manual for Control of Pollutants Generated by Irrigated Agriculture", May, 1978.

The manual will provide guidance in the evaluation of (1) water quality problems resulting from irrigation return flow, and (2) solution to those problems. It will provide the necessary background for evaluation of the applicability of "best management practices" (BMP's) at the local and regional level. The manual presents: (1) background information on the technology involved; (2) methods of evaluation of water quality problems; (3) methods of evaluating alternative management practices; (4) review of problems and solutions being developed in selected areas of the western United States. The presentation will be directed towards regional water quality planning agencies, soil and water conservation agencies, local and regional government officials, irrigation districts, and individual irrigators. Handbook Sources 3 and 5.

(4) "Salinity Management in Irrigated Agriculture", June, 1978.

This project is designed to produce a manual of best management practice for the control of salinity from irrigated agriculture in the western U. S. It is to be based upon structural and non-structural technology which has been demonstrated effective in reducing salt loading to river systems. Educational materials will also be developed to assist in the dissemination of this information to the areawide planners and other user groups. Handbook Source 3 and 5.

(5) "A Manual for -- Evaluating Land Applications of Livestock and Poultry Residue", December 1977.

The objectives of this manual are to:

1. Provide basic information to enable planners to reduce or control nonpoint pollution from livestock and poultry residue land application systems.
2. Provide systematic procedures for evaluating current and future livestock and poultry residue land application systems in terms of agronomic benefit and/or pollution potential.
3. Provide sufficient information to enable planners to integrate the numerous variables into a land application system which makes beneficial use of livestock and poultry residues.

The objectives of this manual will be achieved when the evaluation procedures are used by groups of specialists charged with developing specific practices for state and local areas. Specialists include farmers, engineers, agronomists, hydrologists, soil scientists and economists combining to integrate the numerous variables into the best management system.

This manual provides information to individuals or agencies charged with developing plans for controlling or reducing pollution caused by disposal of livestock and poultry residues on land if that is a problem in a particular instance. Included are guidelines for choosing the most appropriiate methods for particular residues, and individual fields, and cropping practices. Handbook Source 2, 3, and 5.

(6) "Environment Protecting Concepts of Beef Cattle Feedlot Wastes Management", July 1973.

The function of this manual is to serve as a guide to insure consideration and incorporation of pertinent environmental pollution controls in the design and operation of beef cattle feedlots. It has been designed to serve as a reference source for the more detailed information contained in published literature on feedlot design and operation. In addition, the precepts presented in this manual are applicable to other segments of the animal industry. Handbook Source 3 and 5.

(7) "A Manual On: Evaluation and Economic Analysis of Livestock Waste Management Systems", January 1978

The waste management systems suitable for dairy, beef, swine, sheep, and poultry facilities differ from region to region in the United States. This manual identifies the principal regional, environmental, engineering, and economic constraints on alternative waste systems. The objective is, (1) to provide a manual on cost/effective livestock management systems to control pollution from non-NPDES facilities, excluding cattle on range, and (2) to identify and evaluate "no-discharge" management systems.

The scope of the manual will include management of runoff, solid and airborne wastes from non-NPDES animal production facilities, the Manual is prepared for use by farmers, farm planners, Extension personnel, 208 planners, and other planners and decision makers. Handbook Source 2, 3, and 5.

(8) "Environmental Impact Resulting From Unconfined Animal Production". January, 1978.

This report presents an evaluation of the environmental effects arising from production of farm animals in unconfined systems. The differentiation between confined and unconfined production systems is that the wastes generated in a confined system is subject to handling while that in an unconfined system is not. In this report the differentiation between unconfined and confined systems is the same as that for point and nonpoint sources. And, an unconfined system is the same as a grazing system (one in which livestock have access to pasture, range or woodland and utilize the associated forage as a principal source of feed).

Farm animals that are produced in unconfinement are cattle (both dairy and beef), sheep, hogs (primarily sow operations) and goats. Commercial or farm production of poultry (chickens, turkeys, duck) utilize confinement systems exclusively (and, poultry wastes require management as point sources). While horses are sometimes kept in unconfined systems, they pleasure animals rather than farm animals and, thus, are not a direct subject of this report. Handbook Source 2, 3, and 5.

(9) "Nitrogen Management In Irrigated Agriculure" - A State-of-the-Art Review - May, 1978.

A state-of-the-art review of what is now known with respect to nitrogen management in irrigated agriculture. Handboo Source 3, 4, and 5.

HANDBOOK SOURCES

(1) U. S. Environmental Protection Agency
Agriculture and Nonpoint Source Management Division (RD-682)
Washington, D. C 20460

(2) U. S. Department of Agriculture
ARS Information - Room 343A
Federal Center Building - No. 1
Hyattsville, Maryland 20782

(3) National Technical Information Service
5285 Port Royal Road
Springfield, Virginia 22151

(4) Superintendent of Documents
U. S. Government Printing Office
Washington, D. C 20402

(5) Robert S. Kerr
Environmental Research Laboratory
Ada, Oklahoma 74820

APPENDIX B

FEDERAL REGISTER,
March 18, 1976

B-2

federal register

THURSDAY, MARCH 18, 1976

THE NATIONAL ARCHIVES OF THE UNITED STATES
1934

PART III:

ENVIRONMENTAL PROTECTION AGENCY

■

STATE PROGRAM ELEMENTS NECESSARY FOR PARTICIPATION IN THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

Concentrated Animal Feeding Operations

Title 40—Protection of Environment

CHAPTER I—ENVIRONMENTAL PROTECTION AGENCY

[FRL 503-2]

PART 124—STATE PROGRAM ELEMENTS NECESSARY FOR PARTICIPATION IN THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

PART 125—NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

Concentrated Animal Feeding Operations

On November 20, 1975, the Environmental Protection Agency (EPA) proposed regulations for applying the National Pollutant Discharge Elimination System (NPDES) permit program to concentrated animal feeding operations (40 FR 54182). These regulations were proposed in accordance with the June 10, 1975, court order issued following the decision of the Federal District Court for the District of Columbia in the case of *NRDC v. Train* [396 F. Supp. 1393, 7 ERC 1881 (D.D.C. 1975)]. Although EPA is proceeding with the appeal of this case, the Agency is required to proceed with the promulgation of these regulations. For a detailed history of the development of the proposed regulations, see the preamble to the November 20, 1975, publication.

At the time of the November 20, 1975, publication of the proposed regulations EPA solicited comments on all aspects of the regulations and received more than 50 comments in response from industry groups, educational institutions, environmental organizations, federal, state and local agencies and interested persons. The comments have been carefully considered and several changes have been made to the proposed regulations in response to the suggestions made. The most important of these changes are diagrammed as follows and discussed below.

BASIC STRUCTURE OF FEEDLOT PROGRAM
PROGRAM PROPOSED IN NOV. 5 REGULATIONS

Feedlots with 1,000 or more animal units	*Feedlots with less than 1,000 animal units*
Permit required for all feedlots with discharges[1] of pollutants.	Permits required for feedlots with: (1) Discharges[1] of pollutants through a manmade conveyance, or (2) Discharges[1] of pollutants into waters traversing the confined area.

[1] Feedlot not subject to requirement to obtain permit if discharge occurs only in the event of a 25-yr., 24-h., storm event.

NOTE.—All feedlots subject to a case-by-case designation requiring an individual permit.

Basic structure of feedlot program—program promulgated today

Feedlots with 1,000 or more animal units	Feedlots with less than 1,000 but with 300 or more animal units	Feedlots with less than 300 animal units
Permit required for all feedlots with discharges[1] of pollutants.	Permit required if feedlot— 1. Discharges[1] pollutants through a manmade conveyance, or 2. Discharges[1] pollutants into waters passing through or coming into direct contact with animals in the confined area.	No permit required (unless case-by-case designation as provided below).
	Feedlots subject to case-by-case designation requiring an individual permit only after onsite inspection and notice to the owner or operator.	Case-by-case designation only if feedlot— 1. Discharges pollutants through a manmade conveyance, or 2. Discharges pollutants into waters passing through or coming into direct contact with the animals in the confined area; and After onsite inspection, written notice is transmitted to the owner or operator.

[1] Feedlot not subject to requirement to obtain permit if discharge occurs only in the event of a 25 yr, 24-h storm event.

(1) As seen in the diagram above, a lower level cutoff number has been added. Under the program established today, permits are required from feeding operations with less than 1,000 but with 300 or more animals only for those operations which have discharges of pollutants (a) through a man-made conveyance or (b) directly into navigable waters which pass through the confined area. For operations with less than 300 head, no permit application is required unless there is an onsite inspection of the operation and the owner or operator is notified in writing that such application is required.

(2) As was pointed out by numerous commenters, the statement by Senator Edmund Muskie regarding feedlots covered by the permit program provided general guidance rather than a definitive statement of criteria. Although the Agency proposed to adopt the numbers suggested by Senator Muskie, the upper level cutoff numbers established in the July 5, 1973, promulgation (38 FR 18000) of feedlot permit requirements are the basis for the upper levels established today. The numbers published in July 1973 and hereby affirmed require permits for operation with more than 1000 beef cattle; 700 dairy cattle, 2,500 swine; 10,000 sheep; 55,000 turkeys; 100,000 chickens (if the operation has continuous overflow watering); 30,000 chickens (if the operation has a liquid manure handling system); 5,000 ducks; and 500 horses. (See 40 CFR §§ 124.11 (h)(1), 125.4(j)(1), 412.10 and 40 FR 54182.) As pointed out by the commenters the earlier numbers were much better justified by studies and data than were the numbers set forth in Senator Muskie's guidance. Also, maintaining the same upper level numbers will minimize disruption and confusion among those feedlot operators currently subject to the permit program.

(3) For feeding operations with less than 300 animal units, only those operations which (a) have streams passing through the confined area, or (b) have direct discharges to navigable waters will be subject to the possibility of being designated as a concentrated animal feeding operation on a case-by-case basis by a State pollution control Director or the EPA Regional Administrator. No feeding operation with less than 300 animal units will be required to apply for or obtain a permit unless it meets one of the above criteria, and, following an onsite inspection, the owner or operator has been individually notified in writing that a permit application is required.

RESPONSE TO COMMENTS ON THE PROPOSED PROGRAM

Comments received in response to the proposed November 20, 1975, regulations have been entered into the record of the development of these regulations and are available for public inspection at EPA. All comments received have been carefully considered and many have been adopted or substantially satisfied by editorial changes, deletions or additions to the regulations. Several of the major comments and their disposition are discussed below.

1. *The definition of "animal feeding operation"* [(*a*)(*1*)]. Several commenters pointed out that a clarification of this definition was necessary, particularly as to the intent of the vegetation criterion. To accommodate these comments, this part of the definition section has been revised to include post-harvest residues and to make clear that only confined areas which lack vegetation, crops, etc. in every part or portion of the lot or facility are included within the term "animal feeding operation."

Comments were also received concerning the meaning of "an aggregate of 45 days," suggesting that the word "total" be substituted for "aggregate," or that the phrase be changed to read "45 consecutive days." Changes to the number of days were also suggested, specifically to change the number to 30 or 60 days. However, except for the change of the word "aggregate" to "total," meaning that the 45 days are not necessary continuous, no change has been made to the 45 day criterion.

The comments also make clear that it is necessary to reiterate EPA's intent not to require permits from operations without discharges to navigable waters. As stated in the November 20, 1975, proposed regulations:

> It must be emphasized that these regulations do not automatically require applications for permits from every owner or operator of a concentrated animal feeding operation point source. Before a permit is required

there must be a "discharge of a pollutant" from the point source into "navigable waters." If there is no discharge from a particular operation which is a point source, there is no need for a permit. * * * [T]he proposed regulations provide that no permit is required for any concentrated animal feeding operation which discharges pollutants only in the event of a 25 year, 24 hour rainfall event. In addition, although there may be a discharge of a pollutant from a point source, no permit is required if such a discharge does not reach navigable waters.

2. *The definition of "concentrated animal feeding operation"* [(*a*) (2)]. Many comments were received suggesting that this critical term be clarified in several ways.

(a) One commenter pointed out that the word "concentrated" connotes a large number of animals confined in a relatively small area, and indicated that part of the regulations were inconsistent with this plain meaning of the term. The parts of the definition of "concentrated animal feeding operation" beginning with the words "[w]ithout regard to the numbers * * * of animals confined" present a meaning contrary to the ordinary use of the word "concentrated." In order to eliminate this contradiction, additional cutoff numbers have been added to the definition. These numbers would indicate the size of the animal feeding operations which are not, as a general matter, "concentrated" and, therefore, for which, lacking a specific written determination (following a field inspection; see further below) to the contrary, no permit would be required. This de minimis lower level general cutoff is consistent with the decision in *NRDC v. Train* which states that not every "ditch, water bar or culvert" is "meant to be a point source under the Act [Federal Water Pollution Control Act]" (7 ERC 1881 at 1887).

In addition, in response to comments concerning combinations of animals for confined operations, the term "animal unit" is re-established consistent with the term as used in the July 1973 publication. This term is defined and added to the list of definitions for this section.

(b) Many commenters asked for a definition of "measurable wastes." Because it implied the imposition of costly and time-consuming monitoring requirements, the term "measurable wastes" has been deleted. The more consistent term "pollutants," which is defined in section 502(6) of the Federal Water Pollution Control Act (Public Law 92-500; 33 U.S.C. 1251 et seq; the Act), has been inserted instead.

(c) Many commenters also noted the need to clarify the term "navigable waters." This term is fully explained and interpreted in detail at 40 CFR 125.1(p).

(d) Several commenters suggested that the criterion related to waters which "traverse" the operation be clarified. Accordingly, this criterion has been rewritten without the word "traverse" in order to make clear that this criterion relates to waters which come into contact with the animals confined in the operation.

(e) Three commenters pointed out that the words concerning direct discharge were ambiguous in that wastes may be discharged from an animal feeding operation but may not reach navigable waters. These regulations concern only those discharges of animal wastes that enter navigable waters. Thus for example, if discharges leave the feeding operation but do not reach navigable waters because of filter strips or other waste management techniques, no permit is required.

(f) Some comments were received concerning the cutoff numbers used in the definition. The majority of these comments accepted the numbers and urged that they be adopted. One comment suggested higher numbers and a few comments suggested lower numbers. As discussed in more detail above, however, the numbers established in the previous feedlot regulations, published in July 1973, have been reinstated.

(g) Several comments were received in reference to the provision concerning the 25 year, 24 hour storm event. Half of these comments suggested that a 10 year, 24 hour storm event be substituted for the criterion in the proposed regulations. However, consistent with data used in the development of the July 1973 promulgation indicating that such criterion was rational and feasible for all feedlots with 300 or more animal units, the 25 year, 24 hour storm criterion has been retained.

3. *The definition of "man-made"* [(*a*) (3)]. This definition has been amended to reflect four comments recommending a slight expansion of the term.

4. *Application for a permit* [(*b*) (*1*) *and* (2)]. Comments were received indicating that the time period between the application date of March 10, 1977, and the implementation deadline in the Act of July 1, 1977, was inadequate to enable owners and operators to construct pollution control devices. In order to alleviate this problem, the deadline for permit applications has been changed to September 1, 1976. This shortened deadline will not be unduly burdensome because the Short Form B on which the permit applications are to be filed is very brief. (The application fee for the Short Form B is $10). The earlier deadline also provides for more time to comply with the procedural elements of permit issuance, including notice and opportunity for a hearing.

5. *Case-by-case designation* [(*c*)]. Several commenters pointed out a need to specify the criteria listed in this section and to narrow the discretion of the Director or Regional Administrator to designate an animal feeding operation as concentrated and therefore requiring a permit. This section was included in the regulations to provide for flexibility in State pollution control programs which was urged by scores of participants in the public meetings held on this subject. To further define the criteria would defeat the purpose of this provision to provide for site-specific determinations.

However, it is intended that the Director or Regional Administrator should exercise their discretion with respect to facilities having pollution potential. Thus, for operations smaller than 300 animal units only those which (a) have streams passing through the confined area or (b) have direct discharges to navigable waters are subject to this case-by-case designation.

In exercising his discretion, the Director or Regional Administrator will designate a concentrated animal feeding operation only after an onsite inspection and determination that the operation should and could be regulated under the permit program. In addition, before an application is required, the owner or operator of the feedlot will be notified of the application requirement. As with past experience, it is anticipated that the Director or Regional Administrator would exercise this discretion only in exceptional cases.

It bears repeating that owners or operators of point sources are not required to apply for and obtain pollution discharge permits if there is no discharge of pollutants from such point sources into navigable waters. Thus, totally enclosed systems, such as many poultry operations, without discharges into navigable waters are not subject to the permit requirements regardless of their size. Also, no permits would be required from owners or operators of operations which recycle all pollutants to the land, or which absorb all animal wastes in filter strips or otherwise prevent such wastes from reaching navigable waters. Thus, any feedlot owner or operator who uses alternate management techniques and prevents all discharges from reaching navigable waters would not have to obtain a permit.

Because of the importance of promptly making known to other Federal Agencies, States, dischargers, environmentalists and other interested persons the content of these regulations and because of the need to implement this program promptly, the Administrator finds good cause to declare these regulations effective immediately upon publication.

No Inflationary Impact Statement is required by Executive Order 11821 for these regulations since the economic effects will not exceed the criteria established by EPA and approved by the Office of Management and Budget for the preparation of such statements.

Dated: March 10, 1976.

RUSSELL E. TRAIN,
Administrator.

Part 124 of Title 40 of the Code of Federal Regulations, setting forth State program elements necessary for participation in the National Pollutant Discharge Elimination System, is amended as follows:

Subpart A—General

§ 124.1 [Amended]

1. Section 124.1 is amended by deleting subsection (u) and by relettering subsection (v) to (u).

Subpart B—Prohibition of Discharges of Pollutants

§ 124.11 [Amended]

2. Paragraph (h) of § 124.11 is amended by deleting paragraphs (h) (1) and (2); by renumbering paragraphs (h) (3), (4), and (5) to (h) (2), (3), and (4) respectively; and by adding a new paragraph (h) (1) as follows: "(1) Discharges from concentrated animal feeding operations as defined in § 124.82(a) (2)."

Subpart I—Disposal of Pollutants into Wells

§ 124.80 Redesignated 124.81.

3. Subpart I of Part 124 is amended by deleting the title "Disposal of Pollutants into Wells" and by adding a new title "Special Programs," and by renumbering § 124.80 to 124.81.

4. Subpart I of Part 124 is amended by adding a new § 124.82, Concentrated Animal Feeding Operations, as follows:

§ 124.82 Concentrated Animal Feeding Operations.

(a) Definitions.

For the purpose of this section:

(1) The term "animal feeding operation" means a lot or facility (other than an aquatic animal production facility) where the following conditions are met:

(i) Animals have been, are or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12 month period, and

(ii) Crops, vegetation, forage growth or post-harvest residues are not sustained in the normal growing season over any portion of the lot or facility.

Two or more animal feeding operations under common ownership are deemed to be a single animal feeding operation if they are adjacent to each other or if they utilize a common area or system for the disposal of wastes.

(2) The term "concentrated animal feeding operation" means an animal feeding operation which meets the criteria set forth in either (a) (2) (i) or (ii) below:

(i) More than the numbers of animals specified in any of the following categories are confined:

(*a*) 1,000 slaughter and feeder cattle,

(*b*) 700 mature dairy cattle (whether milked or dry cows),

(*c*) 2,500 swine weighing over 55 pounds,

(*d*) 500 horses,

(*e*) 10,000 sheep or lambs,

(*f*) 55,000 turkeys,

(*g*) 100,000 laying hens or broilers (if the facility has continuous overflow watering),

(*h*) 30,000 laying hens or broilers (if the facility has a liquid manure handling system),

(*i*) 5,000 ducks, or

(*j*) 1,000 animal units: *or*

(ii) More than the following numbers and types of animals are confined:

(*a*) 300 slaughter or feeder cattle,

(*b*) 200 mature dairy cattle (whether milked or dry cows),

(*c*) 750 swine weighing over 55 pounds,

(*d*) 150 horses,

(*e*) 3,000 sheep,

(*f*) 16,500 turkeys,

(*g*) 30,000 laying hens or broilers (if the facility has continuous overflow watering),

(*h*) 9,000 laying hens or broilers (if the facility has a liquid manure handling system),.

(*i*) 1,500 ducks, or

(*j*) 300 animal units;

and either one of the following conditions are met:

(*k*) Pollutants are discharged into navigable waters through a man-made ditch, flushing system or other similar man-made device; or

(*l*) pollutants are discharged directly into navigable waters which originate outside of and pass over, across, through or otherwise come into direct contact with the animals confined in the operation.

Provided, however, that no animal feeding operation is a concentrated animal feeding operation as defined above if such animal feeding operation discharges only in the event of a 25 year, 24 hour storm event.

(3) The term "animal unit" means a unit of measurement for any animal feeding operation calculated by adding the followings numbers: the number of slaughter and feeder cattle multiplied by 1.0, plus the number of mature dairy cattle multiplied by 1.4, plus the number of swine weighing over 55 pounds multiplied by 0.4, plus the number of sheep multiplied by 0.1, plus the number of horses multiplied by 2.0.

(4) The term "man-made" means constructed by man and used for the purpose of transporting wastes.

(b) Application for Permit. (1) Any person discharging or proposing to discharge pollutants from a concentrated animal feeding operation, who has not already done so, shall file an application with the Director by September 1, 1976.

(2) (i) Each application must be filed on a Short Form B and completed in accordance with the instructions provided with such form.

(ii) In addition to the information required in the Short Form B the Director may require any applicant to submit such other appropriate information as the Director deems necessary to proceed with the issuance of the permit.

(c) Case-by-case Designation of Concentrated Animal Feeding Operations

Notwithstanding any other provision of this section, the Director or the Regional Administrator may designate as a concentrated animal feeding operation any animal feeding operation not otherwise falling within the definition provided in § 124.82(a) (2) above. In making such designation the Director or the Regional Administrator shall consider the following factors:

(1) The size of the animal feeding operation and the amount of wastes reaching navigable waters;

(2) The location of the animal feeding operation relative to navigable waters;

(3) The means of conveyance of animal wastes and process waste waters into navigable waters;

(4) The slope, vegetation, rainfall, and other factors relative to the likelihood or frequency of discharge of animal wastes and process waste waters into navigable waters; and

(5) Other such factors relative to the significance of the pollution problem sought to be regulated.

Provided, however, that no animal feeding operation with less than the numbers of animals set forth in (a) (2) (ii) above shall be designated as a concentrated animal feeding operation unless such animal feeding operation meets either of the following conditions:

(6) Pollutants are discharged into navigable waters through a man-made ditch, flushing system or other similar man-made device; or

(7) Pollutants are discharged directly into navigable waters which originate outside of and pass over, across, through or otherwise come into direct contact with the animals confined in the operation.

In no case shall a permit application be required from a concentrated animal feeding operation designated pursuant to this section until there has been an onsite inspection of the operation and a determination that the operation should and could be regulated under the permit program. In addition, no application shall be required from an owner or operator of a concentrated animal feeding operation designated pursuant to this section unless such owner or operator is notified in writing of the requirement to apply for a permit.

Part 125 of Title 40 of the Code of Federal Regulations, setting forth policies and procedures for the Environmental Protection Agency's administration of its role in the National Pollutant Discharge Elimination System, is amended as follows:

Subpart A—General

§ 125.1 [Amended]

1. Section 125.1 is amended by deleting paragraph (ii) and by relettering paragraph (jj) to (ii).

§ 125.4 [Amended]

2. Paragraph (j) of § 125.4 is amended by deleting paragraphs (1) and (2); by renumbering paragraphs (3), (4), and (5) to (2), (3), and (4) respectively; and by adding a new paragraph (1) as follows: "(1) Discharges from concentrated animal feeding operations as defined in section 125.51(a) (2)."

Subpart F—Special Programs

3. Part 125 is amended by adding a new Subpart F, Special Programs, an § 125.51 to read as follows:

§ 125.51 Concentrated Animal Feeding Operations.

(a) Definitions.

For the purpose of this subpart:

(1) The term "animal feeding operation" means a lot or facility (other than an aquatic animal production facility) where the following conditions are met:

(i) Animals have been, are or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12 month period, and

(ii) Crops, vegetation, forage growth or post-harvest residues are not sustained in the normal growing season over any portion of the lot or facility.

Two or more animal feeding operations under common ownership are deemed to be a single animal feeding operation if they are adjacent to each other or if they utilize a common area or system for the disposal of wastes. -

(2) The term "concentrated animal feeding operation," means an animal feeding operation which meets the criteria set forth in either (i) or (ii) below:

(i) More than the numbers of animals specified in any of the following categories are confined:

(*a*) 1,000 slaughter and feeder cattle,

(*b*) 700 mature dairy cattle (whether milked or dry cows).

(*c*) 2,500 swine weighing over 55 pounds,

(*d*) 500 horses,

(*e*) 10,000 sheep or lambs,

(*f*) 55,000 turkeys,

(*g*) 100,000 laying hens or broilers (if the facility has continuous overflow watering),

(*h*) 30,000 laying hens or broilers (if the facility has a liquid manure handling system),

(*i*) 5,000 ducks, or

(*j*) 1,000 animal units; *or*

(ii) More than the following numbers and types of animals are confined:

(*a*) 300 slaughter or feeder cattle,

(*b*) 200 mature dairy cattle (whether milked or dry cows),

(*c*) 750 swine weighing over 55 pounds,

(*d*) 150 horses,

(*e*) 3,000 sheep,

(*f*) 16,500 turkeys,

(*g*) 30,000 laying hens or broilers (if the facility has continuous overflow watering),

(*h*) 9,000 laying hens or broilers (if the facility has a liquid manure handling system),

(*i*) 1,500 ducks, or

(*j*) 300 animal units;

and either one of the following conditions are met:

(*k*) Pollutants are discharged into navigable waters through a man-made ditch, flushing system or other similar man-made device; or

(*l*) Pollutants are discharged directly into navigable waters which originate outside of and pass over, across, through or otherwise come into direct contact with the animals confined in the operation.

Provided, however, that no animal feeding operation is a concentrated animal feeding operation as defined above if such animal feeding operation discharges only in the event of a 25 year, 24 hour storm event.

(3) The term "animal unit" means a unit of measurement for any animal feeding operation calculated by adding the following numbers: the number of slaughter and feeder cattle multiplied by 1.0, plus the number of mature dairy cattle multiplied by 1.4, plus the number of swine weighing over 55 pounds multiplied by 0.4, plus the number of sheep multiplied by 0.1, plus the number of horses multiplied by 2.0.

(4) The term "man-made" means constructed by man and used for the purpose of transporting wastes.

(b) Application for Permit. (1) Any person discharging or proposing to discharge pollutants from a concentrated animal feeding operation, who has not already done so, shall file an application with the Regional Administrator by September 1, 1976.

(2) (i) Each application must be filed on a Short Form B and completed in accordance with the instructions provided with such form.

(ii) In addition to the information required in the Short Form B the Regional Administrator may require any applicant to submit such other appropriate information as the Regional Administrator deems necessary to proceed with the issuance of the permit.

(c) Case-by-case Designation of Concentrated Animal Feeding Operations. Notwithstanding any other provision of this section, the Director or the Regional Administrator may designate as a concentrated animal feeding operation any animal feeding operation not otherwise falling within the definition provided in § 125.51(a)(2) above. In making such designation the Director or Regional Administrator shall consider the following factors:

(1) The size of the animal feeding operation and the amount of wastes reaching navigable waters;

(2) The location of the animal feeding operation relative to navigable waters;

(3) The means of conveyance of animal wastes and process waste waters into navigable waters;

(4) The slope, vegetation, rainfall, and other factors relative to the likelihood or frequency of discharge of animal wastes and process waste waters into navigable waters; and

(5) Other such factors relative to the significance of the pollution problem sought to be regulated.

Provided, however, that no animal feeding operation with less than the numbers of animals set forth in (a)(2)(ii) above shall be designated as a concentrated animal feeding operation unless such animal feeding operation meets either of the following conditions:

(6) Pollutants are discharged into navigable waters through a man-made ditch, flushing system or other similar man-made device; or

(7) Pollutants are discharged directly into navigable waters which originate outside of and pass over, across, through or otherwise come into direct contact with the animals confined in the operation.

In no case shall a permit application be required from a concentrated animal feeding operation designated pursuant to this section until there has been an on-site inspection of the operation and a determination that the operation should and could be regulated under the permit program. In addition, no application shall be required from an owner or operator of a concentrated animal feeding operation designated pursuant to this section unless such owner or operator is notified in writing of the requirement to apply for a permit.

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APPENDIX C

BEST MANAGEMENT PRACTICES STATEMENT

BEST MANAGEMENT PRACTICES
AGRICULTURAL NONPOINT SOURCES
WATER POLLUTION

Agricultural nonpoint sources are a broad category covering all crop and animal production activities. Crop production includes both irrigated and non-irrigated production, such as row crops, close grown crops, orchards and vineyards, and fallow land temporarily out of production. Animal production includes such systems as pasture and rangeland grazing, semiconfined feeding and grazing, and concentrated animal feeding operations.

Introduction

This guidance is intended to provide information regarding the control of pollution from a agricultural nonpoint sources, and to supplement information regarding the control of agricultural discharges regulated under the requirements of NPDES. Agricultural production activities provides, on a national scale, significant sources of pollutants which reach both surface and ground waters. These may be either point sources or nonpoint sources, or combinations of the two.

Description of Agricultural Activities

Agricultural nonpoint sources are the crop and animal production systems that result in diffuse runoff, seepage, or percolation of pollutants to the surface and ground waters. There are a number of different activities within each of the systems that may cause water pollution. The runoff, seepage or percolation of pollutants generated by the activities are strongly dependent on climatic events suc as rainfall and snowmelt. In general, they are intermittent and do not represent a continuous discharge. The nature of the pollutants depends on the particular activities underway at the time of the climatic events. Both the nature and amount of pollutants are also dependent on other factors such as soil types, topography, crop and animal types, and crop and animal production methods.

Crop Production

There are five general categories of activities associated with crop production which can produce the potential for nonpoint source pollution:

1. The disturbance of the soil by tillage or compaction by machinery.

2. The alteration of natural vegetative patterns by substituting crop plants for natural vegetation or leaving the soil without vegetative cover.

3. The increase in available nutrients, over the quantity available through natural cycles, by the application of fertilizers.

4. The introduction of chemical compounds not found in significant quantities under natural conditions such as by the application of pesticides.

5. The application of surface or ground waters for the purpose of irrigating crops.

Animal Production

There are three general categories of activities associated with animal production which can produce the potential for nonpoint source pollution:

1. Concentration of animals (and their wastes) in a particular location for an extended period of time such as at feeding areas.

2. Overgrazing of range and pasture lands that removes vegetative cover from the land.

3. Concentration of animals instreams or along stream banks in such numbers as to cause disturbance of the stream bottoms or banks, or result in direct deposit of manure into streams.

Identification of Pollutants

Six general types of nonpoint source pollutants that may result from activities associated with agricultural production systems are:

1. Sediment: Sediments, by volume, are the most serious pollutants resulting from agricultural production. They include principally mineral fragments resulting from the erosion of soils but may also include crop debris and animal wastes. Sediments can smother organisms in water bodies by forming bottom blankets, interfere with the photosynthetic processes by reducing light penetration, and act as carriers of nutrients and pesticides. Deposits also may fill reservoirs and hinder navigation.

2. Nutrients: Nutrients, above the natural background levels of an area may result from fertilizer applications and animal wastes. Soluble nutrients may reach surface and ground water through runoff, seepage, and percolation. Ions may be adsorbed on soil particles and reach surface water through sedimentation processes. Nutrients may also reach surface water by direct washoff of animal wastes and recently applied fertilizer.

Excessive nutrients can lead to imbalance in the natural nutrient cycles and cause eutrophication. In some cases, excessive nutrients can be a health hazard.

3. Pesticides: Pesticides which are applied in the agricultural production unit may be insoluble or soluble. The entrance of pesticides into the surface or ground waters follows approximately the same patterns as nutrients. Pesticides may cause acute toxicity problems in the water bodies or insidious toxicity problems through the entire food chain.

4. Organic Materials: Animal wastes and crop debris are the principal organic pollutants that result from agricultural production. They may reach surface waters through direct washoff, or, in their soluble form, reach both surface and ground waters through runoff, seepage or percolation. The organic materials place an oxygen demand on the receiving waters during their decomposition. In addition, they may lead to other problems such as tastes, odors, color, and nutrient enrichment.

5. Salinity (TDS): The necessity of leaching to remove, or prevent the damaging accumulation of salts in the root zone of plants has the potential of inducing subsequent quality problems in both surface and ground waters if agricultural waters are not properly managed. Percolating water may reach ground water through further deep percolation, or move laterally into surface water bodies. The problem becomes more pronounced when the applied irrigation water initially contains dissolved solids which will become more concentrated as the plants remove water for their use. Severity of pollution depends not only on the nature of the receiving waters but also on the nature of the uses of the receiving waters.

6. Microorganisms: Any potential disease-causing microorganisms (pathogens) in water are a matter of concern to the health and safety of the water users. Animal wastes are the principal source of pathogenic microorganisms resulting from agricultural production. Pathogens reach the water bodies through the same routings as the animal wastes.

Basis For Best Management Practices Development

Best Management Practices for agricultural production are the most practical and effective measure or combination of measures, which when applied to the agricultural management unit, will prevent or reduce the generation of pollutants to a level compatible with water quality goals. They often enhance the productivity of the soil as well as control pollution.

Because of the variability in production methods, crops and animals, soil types, topography, climate, etc., the BMP for any specific agricultural management unit or area will vary. The selection of Best Management Practices for a particular agricultural management unit or area is a complex process. Any measure or combination of measures applied to an agricultural management unit or area which will achieve water quality goals is a potential BMP. However, the measures are generally the type that are incorporated into a soil and water conservation plan as developed by a landowner or land user, with the assistance of a conservation district and/or the Soil Conservation Service, Extension Service, Forest Service, and others.

The principal emphasis should be placed on measures that will prevent or control the runoff, seepage or percolation of pollutants from crop or animal production management units. Preventive measures must be fully integrated into the total production management system of the agricultural management units. In essence, the soils, nutrients and pesticides should be kept on the land where they perform their intended agricultural function.

Because of the widespread nature of sediment runoff, erosion control measures should be a principal means of controlling pollution from each agricultural management unit. Control of erosion not only will prevent soils from leaving the land, but also will materially reduce the nutrients and pesticides that reach the nation's waters adsorbed to soil particles. Where necessary, to further prevent or reduce the entrance of sediments into water bodies, supplemental measures such as debris and sediment retention basins should be utilized.

In cases where excess amounts of nutrients, pesticides and animal wastes cause particular problems in surface or ground waters, additional control measures may be necessary. These measures might relate, for example, to the application (timing and amount) of fertilizers and pesticides, the prevention of the concentration of animals, and the collection and adequate disposal of the animal wastes. Salinity buildup resulting from irrigation must be analyzed in terms of the particular problem with subsequent development of appropriate measures.

Description of Prevention and Reduction Measures

Measures which can be applied to an agricultural management unit to prevent or reduce pollutants from reaching surface or ground waters can be generally classified into four categories. They are: (1) structural measures, (2) conservation cropping systems and animal management systems, (3) quantitative and qualitative management of cropping system inputs, (4) vegetative measures.

Structural measures generally involve some physical method designed to reduce erosion or prevent sediment runoff. They include such things as barriers applied at the source such as terraces, conveyance systems to enhance non-erodable flows such as waterways and drop structures, and catchment systems for the final clarification such as debris basins. Off-stream watering points, controlled access watering points at water bodies, diversions around feeding areas, and manure trapping basins are considered to be structural measures.

Cropping systems and animal management systems involve the spacial and sequential arrangement of crop plant and animal populations. The arrangement of crops on a field such as strip cropping, crop rotation such as sod-forming grass rotation systems, and tillage methods such as minimum tillage can significantly reduce pollutant transport. Control of animal populations so as to prevent overgrazing or the concentration of animals in particular locations can reduce erosion, sediment runoff, and the runoff of concentrated animal wastes.

Inputs into cropping systems which are not efficiently utilized can become potential pollutants. Nutrient and pesticide applications should be matched to the immediate needs of the agricultural production systems. The timing of the applications should take into consideration external hydrologic forces. The efficient use of irrigation water can materially reduce the salinity buildup problems associated with runoff, seepage, and percolation of the water not utilized by the plants.

Vegetative covering on bare, or exposed soils is any crop planted solely to prevent, or control erosion and sediment runoff. It can be used during the winter months, between regular crops during the growing season, or where denuded areas have resulted from overgrazing or some other activity. The vegetative cover protects the bare ground from the erosive energy of falling rain and flowing runoff water and filters out sediment actually being transported in the runoff water leaving the site.

Information Sources

The prevention and reduction measures outlined in the foregoing are generally described in "Methods and Practices for Controlling Water Pollution from Agricultural Nonpoint Sources," EPA-430/9-73-015. Oct 1973. Data on control of dust is presented in "Investigation of Fugitive Dust, Volume 1: Sources, Emissions, and Control" EPA-450/3-74-036a June, 1974, Specific information on the application of the measures for agricultural nonpoint sources and water quality management is contained in "Control of Water Pollution from Cropland, Volume I " USDA, ARS and EPA, ORD. November 1975. "Interim Report on Loading Functions For Assessment of Water Pollution from Nonpoint Sources" EPA; ORD.

November, 1975 provides data for assessing the problem. Information on specific aspects of agricultural nonpoint source pollutants and their control can be found in research reports of EPA, USDA, and other Federal agencies, State and local agencies, colleges and universities, and agricultural trade associations and in grazing and range management documents by these groups.

Design information on various conservation methods can be obtained from Soil Conservation Service handbooks. Specific information on particular locations can be obtained from SCS Field Offices, the Extension Service, soil and water conservation district offices, and other informed agencies and groups.